

Requirements Analysis for the Integration of Simulation and Naval Decision Support Tools

Elizabeth Hosang
CAE Inc.

Prepared By:
CAE Inc.
1135 Innovation Drive,
Ottawa, ON K2K 3G7

Contractor's Document Number: 5897-002 Version 02
PWGSC Contract Number: W7707-145734 Task 10
Technical Authority: Mark Hazen, 902-426-3100 x176

Disclaimer: The scientific or technical validity of this Contract Report is entirely the responsibility of the Contractor and the contents do not necessarily have the approval or endorsement of the Department of National Defence of Canada.

Contract Report
DRDC-RDDC-2017-C077
March 2017



CAE Inc.

1135 Innovation Drive
Ottawa, Ont., K2K 3G7 Canada
Tel: 613-247-0342
Fax: 613-271-0963

**REQUIREMENTS ANALYSIS
FOR THE INTEGRATION OF SIMULATION
AND NAVAL DECISION SUPPORT TOOLS**

CONTRACT #: W7707-145734

FOR

**MARK HAZEN, DEFENCE SCIENTIST / MARITIME DECISION
SUPPORT, DEFENCE R&D CANADA – ATLANTIC RESEARCH CENTRE**

9 Grove Street, Dartmouth, NS

22 March 2017

Document No. 5897-002 Version 02

© Her Majesty the Queen in Right of Canada, as represented by the Minister of National Defence, 2017

© Sa Majesté la Reine (en droit du Canada), telle que représentée par le ministre de la Défense nationale, 2017

APPROVAL SHEET

Document No. 5897-002 Version 02

Document Name: Requirements Analysis
for the Integration of Simulation
and Naval Decision Support Tools

Primary Author

*Originally signed by
Elizabeth Hosang*

Name Elizabeth Hosang
Position Software Architect

Reviewer

*Originally signed by
John Brennan*

Name John Brennan
Position Senior Technical Specialist

Approval

*Originally signed by
Damon Gamble*

Name Damon Gamble
Position Project Manager

REVISION HISTORY

<u>Revision</u>	<u>Reason for Change</u>	<u>Origin Date</u>
Version 01	Initial draft document issued.	22 March 2016
Version DRAFT B	Initial Client Comments addressed.	03 June 2016
Version DRAFT C	Second set of Client Comments addressed.	08 July 2016
Version 01	Final version released.	02 September 2016
Version 02	Parent project references corrected in Background section.	22 March 2017

TABLE OF CONTENTS

1	INTRODUCTION.....	1
1.1	Background	1
1.2	Objective	2
1.3	This Document	2
2	REFERENCES.....	3
2.1	Mandatory References	3
2.2	Guidance Documents	3
2.3	Referenced Documents.....	3
3	BACKGROUND	4
3.1	Terms	4
3.2	Analysis System Architecture	5
4	DATA MODEL	7
4.1	Data Model Overview	7
4.2	Data Management	7
4.3	Message Bus Overview	7
4.4	System Health Topics.....	8
4.5	Command and Control Topics	9
4.5.1	Incoming Data.....	9
4.5.2	External Interface Topic	9
4.6	Planning Topics	10
4.7	Import Message Formats Supported by C2 Gateway	10
4.8	Publish Formats Supported by C2 Gateway	11
4.8.1	File Drop Interface	11
5	FUNCTIONAL REQUIREMENTS	12
5.1	Planning Tool Use Cases	12
5.2	C2 Gateway Use Cases	12
5.3	Use Case 1 – Import Incoming Data.....	13
5.3.1	Use Case Description	13
5.3.2	Actions	13
5.3.3	Requirements	13
5.3.4	Issues	15
5.4	Use Case 2 – Gateway Detects a file in the File Drop Interface	15
5.4.1	Use Case Description	15
5.4.2	Actions	15
5.4.3	Requirements	16
5.4.4	Issues	16

5.5	Use Case 3 – Error Occurs in Parsing a Message	16
5.5.1	Use Case Description	16
5.5.2	Actions	17
5.5.3	Requirements	17
5.5.4	Issues	17
5.6	Use Case 4 – Publish Heartbeat	18
5.6.1	Use Case Description	18
5.6.2	Actions	18
5.6.3	Requirements	18
5.6.4	Issues	18
5.7	Use Case 5 – Gateway Receives a Start Command	19
5.7.1	Use Case Description	19
5.7.2	Actions	19
5.7.3	Requirements	19
5.7.4	Issues	19
5.8	Use Case 6 – Gateway Receives a Stop Command	20
5.8.1	Use Case Description	20
5.8.2	Actions	20
5.8.3	Requirements	20
5.8.4	Issues	20
5.9	Use Case 7 – Gateway Receives a Shutdown Command	20
5.9.1	Use Case Description	20
5.9.2	Actions	21
5.9.3	Requirements	21
5.9.4	Issues	21
5.10	Use Case 8 – Gateway Boots Up	21
5.10.1	Use Case Description	21
5.10.2	Actions	22
5.10.3	Requirements	22
5.10.4	Issues	22
5.11	Use Case 9 – Publish Data	23
5.11.1	Use Case Description	23
5.11.2	Actions	23
5.11.3	Requirements	23
5.11.4	Issues	24
5.12	Use Case 10 – User Creates an External Interface	24
5.12.1	Use Case Description	24
5.12.2	Actions	24
5.12.3	Requirements	25
5.12.4	Issues	25
5.13	Use Case 11 – User Deletes an External Interface	25
5.13.1	Use Case Description	25

5.13.2	Actions	26
5.13.3	Requirements	26
5.13.4	Issues	26
5.14	Use Case 12 – User Edits an External Interface	27
5.14.1	Use Case Description	27
5.14.2	Actions	27
5.14.3	Requirements	27
5.14.4	Issues	28
5.15	Use Case 13 – Publish List of External Interfaces	28
5.15.1	Use Case Description	28
5.15.2	Actions	28
5.15.3	Requirements	28
5.15.4	Issues	29
6	TECHNICAL REQUIREMENTS	30
6.1	Technologies	30
6.1.1	Integrated Development Environment	30
6.1.2	Development Language	30
6.1.3	XML Editor	30
6.2	GFE/GFI	30
6.2.1	Third Party Libraries	31
7	CONCLUSIONS AND RECOMMENDATIONS	32
7.1	Phased Implementation	32
7.1.1	Phase 1	32
7.1.2	Phase 2	32
7.1.3	Phase 3	33
APPENDIX A	ADDITIONAL INFORMATION	A-1
A.1	Definitions and Acronyms	A-1

LIST OF FIGURES

Figure 3-1: Analysis System Architecture..... 5

LIST OF TABLES

Table 5-1: Planning Tool Use Cases.....	12
Table 5-2: C2 Gateway Use Cases.....	12
Table 5-3: Use Case 1 Actions.....	13
Table 5-4: Use Case 1 C2 Gateway Requirements	13
Table 5-5: Use Case 1 C2 Data Model Library Requirements	14
Table 5-6: Use Case 1 Issue List	15
Table 5-7: Use Case 2 Actions.....	15
Table 5-8: Use Case 2 C2 Gateway Requirements	16
Table 5-9: Use Case 2 C2 Data Model Library Requirements	16
Table 5-10: Use Case 3 Actions.....	17
Table 5-11: Use Case 3 C2 Gateway Requirements	17
Table 5-12: Use Case 3 C2 Data Model Library Requirements	17
Table 5-13: Use Case 4 Actions.....	18
Table 5-14: Use Case 4 Gateway Requirements	18
Table 5-15: Use Case 4 Issues	18
Table 5-16: Use Case 5 Actions.....	19
Table 5-17: Use Case 5 C2 Gateway Requirements	19
Table 5-18: Use Case 6 Actions.....	20
Table 5-19: Use Case 6 C2 Gateway Requirements	20
Table 5-20: Use Case 7 Actions.....	21
Table 5-21: Use Case 7 C2 Gateway Requirements	21
Table 5-22: Use Case 8 Actions.....	22
Table 5-23: Use Case 8 C2 Gateway Requirements	22
Table 5-24: Use Case 8 Issues	22
Table 5-25: Use Case 9 Actions.....	23
Table 5-26: Use Case 9 Gateway Requirements	23
Table 5-27: Use Case 9 Library Requirements	24
Table 5-28: Use Case 10 Actions.....	24
Table 5-29: Use Case 10 C2 Gateway Requirements	25
Table 5-30: Use Case 11 Actions.....	26
Table 5-31: Use Case 11 C2 Gateway Requirements	26
Table 5-32: Use Case 12 Actions.....	27
Table 5-33: Use Case 12 C2 Gateway Requirements	27
Table 5-34: Use Case 13 Actions.....	28
Table 5-35: Use Case 13 Gateway Requirements	28
Table 5-36: Use Case 13 Issues	29

EXECUTIVE SUMMARY

This document analyzes Use Cases for a software application that will be used as part of a Naval Command and Control system. Requirements derived from the Use Cases are identified.

1 INTRODUCTION

1.1 Background

The Defence Research and Development Canada (DRDC) Maritime Information Warfare (MIW) Program responds to specific guidance from the Royal Canadian Navy (RCN) to enhance command team effectiveness. This is achieved through improvements to information management techniques and the promotion of greater situational awareness (SA). The MIW Program includes projects that focus on future Naval Command and Control (C2) systems and decision support for the integration and prioritization of information within the Naval warfare domain. This document was produced for DRDC-Atlantic's Human Factors Support Standing Offer (W7711-145734) Task 10 – Investigation of the Integration of Simulation and Naval Decision Support Tools. It was produced by CAE Inc. for the Technical Authority (TA):

Mark Hazen
Defence Scientist, Maritime Decision Support
DRDC-Atlantic
6 Grove Street
Halifax, NS B2Y 3Z7
Telephone: (902) 426-3100 x176
Fax: (902) 426-9654
mark.hazen@drdc-rddc.gc.ca

DRDC is investigating the development of command planning tools that integrate with current and future combat management and command decision tools. Under projects 01DA (Next Generation Naval Command and Control System), 01DB (Integration of Command Decision Support), and WBE 3 (Predictive Situational Awareness), DRDC intends to demonstrate simulation based planning tools to support Naval command teams.

A fundamental requirement for these projects is the ability to assess the usefulness to command teams of various simulation-based command decision aids and that usefulness is expected to rely upon the ability to exchange data between planning tools and the combat systems.

The Simulation Interoperability Standards Organization (SISO) and North Atlantic Treaty Organization (NATO) have developed standards (Coalition Battle Management Language (C-BML) and Military Scenario Definition Language (MSDL)) to assist in this type of effort, and the standards have been implemented in a number of nations, but not recently in Canada. The two standards are currently serving as the basis of a new standard known as C2SIM.

The aim of this work package is to investigate the current status of the standards, determine their applicability to the Naval decision aid problem, create an implementation application programming interface (API), and demonstrate its use in connecting simulation based tools to a Naval command system.

1.2 Objective

The aim of this work is to identify the requirements for a software library that would support C-BML and MSDL as the interface to other systems in a Maritime Command and Control system.

1.3 This Document

This document comprises the following sections:

Section 1 – Introduction: This section provides the background, identifies the objective, describes the high level approach, and outlines the report.

Section 2 – References: This section provides a list of the process documents related to this project.

Section 3 – Background: This section provides background information about the environment and larger system of the components to be built.

Section 4 – Data Model: This section presents information on the Data Model to be used in the overall system.

Section 5 – Functional Requirements: This section presents derived requirements grouped with the use cases from which they were derived.

Section 6 – Technical Requirements: This section presents the tools and software required to develop the target system.

Section 7 – Conclusions and Recommendations: This section presents recommendations for developing the target system.

Appendix A – Additional Information: This section contains the list of Acronyms used in this document.

2 REFERENCES

2.1 Mandatory References

[W7707-145734] Statement of Work for Investigation of the Integration of Simulation and Naval decision Support Tools.

[P16-103-0165484-001-03] TIP Investigation of the Integration of Simulation and Naval Decision Support Tools, 11 December 2015.

2.2 Guidance Documents

[5007-001] Quality Manual, CAE document 5007-001.

2.3 Referenced Documents

[5897-001] Investigation of the Integration of Simulation and Naval Decision Support Tools, CAE document 5897-001.

3 BACKGROUND

This section describes the background and assumptions that were made in analyzing the requirements for the system.

3.1 Terms

The following terms are used in the use cases and the derived requirements:

- Naval C2 Environment – A network of applications, or system of systems, that are used to conduct Naval operations and/or simulations. This environment may include systems used to perform actual Command and Control (C2), including the distribution of orders. It may include Computer Generated Forces (CGF) applications such as Joint Semi-Automated Forces (JSAF), that are used to simulate the behaviour of naval assets during a training or planning exercise.
- Analysis System – The system being designed to support Course of Action Analysis. It consists of the Testbed Plugin Architecture with simulations and/or services as plugins. See Figure 3-1.
- C2 Data Model Library or C2Lib – A software component to be written under this task. It provides the implementations of the protocols that are understood by the Analysis System and provides functions for mapping data from external the external protocols into the format used internally by the Analysis System.
- C2 Gateway – A software component to be written under this task. It is responsible for interfacing to external C2 systems, both importing and exporting data.
- External Systems – Any pre-existing software application or system that may be deployed in the Naval C2 environment. This term may describe CGF systems such as JSAF or Virtual Battlespace 3 (VBS3) as well as actual C2 systems that are used to issue orders such as Combat Management Systems (CMS), etc.
- C-BML Server – A software system that receives C-BML or MSDL messages from one C2 system and distributes them to other C2 system(s) in the Naval C2 environment.
- C2SIM – The new standard being developed by SISO to supersede the C-BML and MSDL standards.
 - The terms C2SIM and C2SIM compliant have been used in some research documents to refer to the combined use of C-BML and/or MSDL, applying to the relevant standard, e.g., the use of C-BML for conveying Orders, Requests and Reports, and the use of MSDL for capturing initialization or snapshot data. The same term, C2SIM, is also the name of the new standard being developed by SISO. Uses of the term C2SIM in this document refer to the new standard.

- Joint Consultation, Command, and Control Information Exchange Data Model (JC3IEDM) – A logical database model developed to provide interoperability between the C2 systems of different nations.
- Operational Database (ODB) – The Canadian implementation of the JC3IEDM model.

3.2 Analysis System Architecture

The architecture of the Analysis System is comprised of a number of components communicating via a shared Message Bus. The architecture is shown in Figure 3-1 below.

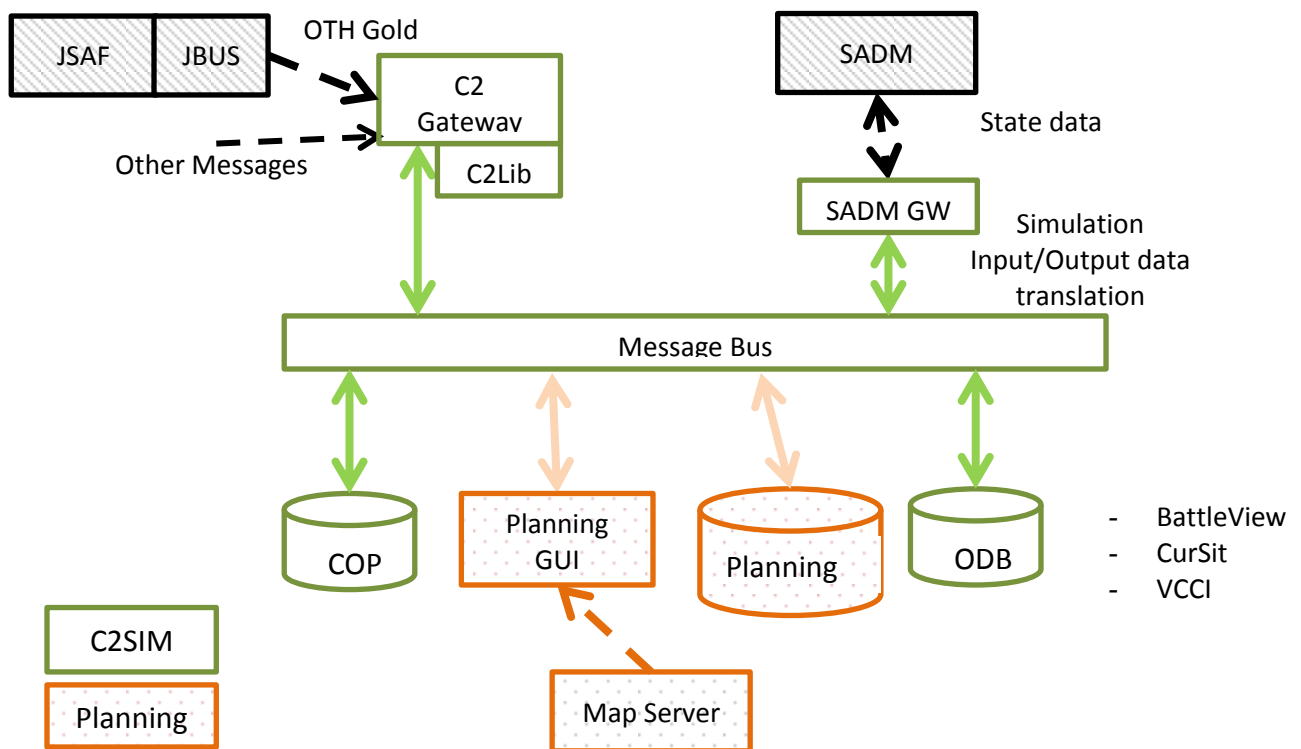


Figure 3-1: Analysis System Architecture

Notes on Figure 3-1:

- The system and its functions are broken into three categories:
 - C2SIM: These components represent the ground truth and existing entities (components with green outline and no fill).

- Planning: These components represent Planning tools and the proposed courses of action developed using them (components with orange outline and dot background).
- System: These functions provide general maintenance operations (not shown in diagram).
- In Figure 3-1 the external systems are shown with black outlines and striped fill. The Map Server can be considered an external system, but is shown in the same color as the Planning components because of the way it will be integrated with the Planning GUI.
- The Common Operating Picture (COP), ODB, and Planning may all be instances of the ODB as implemented by the Canadian Land Command Support System (LCSS):
 - The ODB contains Blue Force (Own Force) information – the assets that can be directed by planning tools.
 - The COP contains all other information – Hostile forces, Other forces, environment, weather, etc.
 - The Planning database contains plans in the form of Action Tasks that make use of the entities in the ODB. The Plans Database (DB) supports multiple plans, representing different courses of action to be taken.
- Interfaces are needed for each database to subscribe to data on the Message Bus and determine whether it should be stored in that database. These are not shown in the figure.
- The Message Bus is implemented using ActiveMQ.
- The C2 Gateway is the interface responsible for communications with external C2 systems.
- The C2 Lib is the C2 Data Model Library utility that converts from other message formats to the internal data model.

4 DATA MODEL

4.1 Data Model Overview

The details of the Data Model (LDM) are still being resolved. The initial proposal is to use the C2SIM-LDM, currently being developed by SISO. The first draft should be available in June 2016.¹

However, this may change if the Army's Operational Data Base (ODB) is used for the three databases shown in the proposed Architecture. The ODB is based on the JC3IEDM schema.

4.2 Data Management

Data received from external systems needs to be saved in one of the databases, depending on the data type.

Rather than have the C2 Gateway parse the data to determine its destination, C2 Gateway will publish data and the databases will determine whether or not to store the data.

C2 data published on the Message Bus will be in XML format.

4.3 Message Bus Overview

The Message Bus is used to communicate between the components in the Analysis System. The Message Bus is based on ActiveMQ, which supports subscription by users. Messages are published on the bus with a Topic. Subscribers use the Topic to determine which messages they are interested in.²

The Topics used for the Analysis System fall into the same categories as the functions in Figure 3-1. The proposed Topics are:

1. System Topics – Used for system health.
2. Command and Control – Used for reports of data from incoming systems.
3. Planning – Used for exchange of Course of Analysis data within the Analysis System.

The Topics that have been identified are presented in more detail below.

¹ As of 23 June 2016, the C2SIM-LDM was not sufficiently mature for the purposes of this task, so the decision was made to use C-BML Light.

² More information on ActiveMQ can be found on the <http://activemq.apache.org/> website.

4.4 System Health Topics

System Health topics are used to monitor the health of the Analysis System components, both for periodic updates and error reports.

The main topic is SYSTEM_HEALTH. Its subtopics and attributes are listed below:

- SYSTEM_HEALTH:
 - HEARTBEAT (subtopic)
 - uptime : double (amount of time the component has been active)
 - name : string (name of the component reporting its heartbeat)
 - hostname : string
 - IP address : string
 - time : datetime (time the heartbeat is reported)
 - information : text (general information about the component)
 - status : error or normal
 - SYSTEM_ERROR
 - name : string (this is the same name as is used in the heartbeat)
 - timeReported : datetime
 - error : text
 - SYSTEM_CONTROL
 - Used to start/stop the Analysis System components at the same time. Details of the topic To Be Determined.
 - SYSTEM_METRICS
 - This may be taken from the ActiveMQ metrics capability.

4.5 Command and Control Topics

4.5.1 Incoming Data

When data is received from an external system, it is published to the Message Bus by the C2 Gateway. The databases which have subscribed to incoming data topics detect the new data and determine whether they should store the data.

- EXTERNAL_DATA
 - CBML
 - ORDER
 - REPORT
 - REQUEST
 - STATUS_UPDATE (MSDL)
- MSDL sub-topic fields:
 - xml : text
 - receivedTime : dateTime
 - source : text (system that originated the data)
 - published : dateTime – time data was published by source system)

All three subtopics under CBML have the same fields as MSDL.

If an unparseable message is received it is reported as a system error.

4.5.2 External Interface Topic

The Planning GUI will allow the user to publish data to some or all of the defined External Interfaces. In order to present the user with a list of the available interfaces, the Planning GUI needs the list of interfaces. The C2 Gateway must make this list available.

The External Interface list includes both a label for the interface, and the Interface type. The Interface type is required because some interfaces may not accept data imports, some interfaces may not accept certain types of data, and some interfaces may require additional data be specified.

The External Interface publishes the list of external interfaces to the Message Bus. Data published on the Message Bus remains available for the life of the bus. The Planning GUI can get the list from the Message Bus whenever it is required.

The topic for the External Interface list is shown below. It is a sub-topic of the C2 topic:

1. EXTERNAL_INTERFACES

- a. name : string
- b. type : string

For the sake of fault tolerance, the C2 Gateway should check periodically to verify that the list is still valid.

4.6 Planning Topics

The full set of Planning Topics is still evolving. One topic that is relevant to the C2 Gateway is the Export topic. The C2 Gateway subscribes to the topic and publishes the attached data to the appropriate interface.

1. EXPORT_TO_C2

- a. Topic meant for C2 Gateway. Causes export of data.
- b. Topic fields:
 - i. xml : text
 - ii. intendedReceiver : text
 - iii. publishedTime : dateTime

Other topics will be defined as the design of the Analysis System is advanced, and fall outside the scope of this document.

4.7 Import Message Formats Supported by C2 Gateway

The formats of imported data that can be parsed by the C2 Gateway are listed below, in order of preference for implementation:

1. GCI+
2. OTH-Gold
3. AIS sentences in NMEA format

4. Link 11/16/22
5. CMS330 Messaging
6. Other C2 Interfaces – C2SIM, C-BML, MSDL

4.8 Publish Formats Supported by C2 Gateway

The formats of data that can be published by the C2 Gateway are listed below, in order of preference for implementation:

1. NMEA
2. OTH Gold
3. C-BML
4. MSDL

4.8.1 File Drop Interface

In addition to interfaces to the identified external systems, the C2 Gateway requires a File Drop interface. This interface consists of a Windows directory that the C2 Gateway watches. Whenever a new text file is written to the directory, the C2 Gateway parses the contents of the file, and moves the file to a “Processed” directory. The contents of the file may be any format that can be parsed by the C2 Gateway. The use of this gateway allows testing of the C2 Gateway without requiring a live interface to an external system.

5 FUNCTIONAL REQUIREMENTS

The Requirements for the system are derived from a set of use cases. The use cases and the resulting Requirements are listed in the sections below.

5.1 Planning Tool Use Cases

The following use cases have been identified for the Planning Tool. They are captured here in Table 5-1: Planning Tool Use Cases although only the last one affects the C2 Gateway and the C2 Data Model Library.

Table 5-1: Planning Tool Use Cases

ID	Test Case Description
PT-1	Planning GUI requests data from ODB/COP database.
PT-2	Planning GUI requests data from Map Server.
PT-3	Planning GUI requests data from Planning DB.
PT-4	Planning GUI stores data in Planning DB.
PT-5	Export Plan.

5.2 C2 Gateway Use Cases

The following use cases have been identified for the C2 Gateway.

Table 5-2: C2 Gateway Use Cases

ID	Test Case Description
CG-1	Import Incoming Data (C2)
CG-2	Gateway detects a file in the File Drop Interface
CG-3	Error occurs in parsing a message
CG-4	Publish Heartbeat
CG-5	Gateway receives a Start Command
CG-6	Gateway receives a Stop Command
CG-7	Gateway receives a Shutdown Command
CG-8	Gateway Boots up
CG-9	Publish Data
CG-10	User creates an External Interface

ID	Test Case Description
CG-11	User deletes an External Interface
CG-12	User edits an External Interface
CG-13	Publish list of External Interfaces

The uses cases are discussed in more detail in the sections below.

5.3 Use Case 1 – Import Incoming Data

5.3.1 Use Case Description

The C2 Gateway receives incoming data from another system. The data is in a format native to the system that sent it. The list of interfaces supported by the system is defined in Section 4.7.

5.3.2 Actions

The following Table 5-3 lists the actions performed by the actors in this use case:

Table 5-3: Use Case 1 Actions

Seq. No.	Description
1.1	C2 Gateway receives incoming data from an External System.
1.2	C2 Gateway passes data to C2 Data Model Library for translation.
1.3	C2 Data Model Library translates the data from the native external format to the internal format used by the Analysis System. The output is in XML format.
1.4	C2 Gateway publishes the translated data on the Message Bus with the EXTERNAL_DATA Topic.

5.3.3 Requirements

The following Table 5-4 and Table 5-5 list the Requirements that were derived from the use case:

Table 5-4: Use Case 1 C2 Gateway Requirements

Req. No.	Description
CG-1.1	The C2 Gateway interfaces with external systems. (Sub-requirements need to be defined for each of the interface types supported.)

Req. No.	Description
CG-1.1.1	The C2 Gateway interfaces with systems that use OTH-Gold.
CG-1.1.2	The C2 Gateway interfaces with systems that use GCI+.
CG-1.1.3	The C2 Gateway interfaces with systems that use AIS sentences.
CG-1.1.4	The C2 Gateway interfaces with systems that use Link 11.
CG-1.1.5	The C2 Gateway interfaces with systems that use Link 16.
CG-1.1.6	The C2 Gateway interfaces with systems that use Link 22.
CG-1.1.7	The C2 Gateway interfaces with systems that use CMS 330.
CG-1.1.8	The C2 Gateway interfaces with systems that use C-BML version 1.0.
CG-1.1.9	The C2 Gateway interfaces with systems that use MSDL version 1.0.
CG-1.2	The C2 Gateway publishes data on the Message Bus with the EXTERNAL_DATA topic.

Table 5-5: Use Case 1 C2 Data Model Library Requirements

Req. No.	Description
CL-1.1	The C2 Data Model Library maps data in OTH-Gold format to the internal data format of the Analysis System.
CL-1.2	The C2 Data Model Library maps data in GCI+ format to the internal data format of the Analysis System.
CL-1.3	The C2 Data Model Library maps data in AIS sentences (NMEA) into the internal data format of the Analysis System.
CL-1.4	The C2 Data Model Library maps data in Link 11 format into the internal data format of the Analysis System.
CL-1.5	The C2 Data Model Library maps data in Link 16 format into the internal data format of the Analysis System.
CL-1.6	The C2 Data Model Library maps data in Link 22 format into the internal data format of the Analysis System.
CL-1.7	The C2 Data Model Library maps data in CMS 330 format into the internal data format of the Analysis System.
CL-1.8	The C2 Data Model Library maps data in C-BML version 1.0 format into the internal data format of the Analysis System.
CL-1.9	The C2 Data Model Library maps data in MSDL version 1.0 format into the internal data format of the Analysis System.

5.3.4 Issues

The following issues represent risks that need to be addressed before the implementation can be completed.

Table 5-6: Use Case 1 Issue List

ID	Issue Description
RI-1	The internal data format used by the Analysis System needs to be defined. ³

5.4 Use Case 2 – Gateway Detects a file in the File Drop Interface

5.4.1 Use Case Description

A file is written to the File Drop Interface.

5.4.2 Actions

The following Table 5-7 lists the actions performed by the actors in this use case:

Table 5-7: Use Case 2 Actions

Seq. No.	Description
1.1	A file is written to the directory that acts as the File Drop in folder.
1.2	The C2 Gateway detects the presence of the file once it has been written.
1.3	The C2 Gateway reads the file and passes it to the C2 Data Model Library for translation.
1.4	The C2 Data Model Library determines the protocol / format of the message and parses it.
1.5	The C2 Gateway publishes the translated data on the Message Bus with the EXTERNAL_DATA Topic.
1.6	The C2 Gateway moves the file from the File Drop in folder to the Processed folder.

³ The original plan was to use the new C2SIM-LDM. However, as of 23 June, 2016, the model was not mature enough for use, and no XSD file was defined for it. As a result, the decision was made to use C-BML Light. Since this is an interim measure, the Risk Item is left here for future reference.

5.4.3 Requirements

The following Table 5-8 lists the Requirements that were derived from the use case:

Table 5-8: Use Case 2 C2 Gateway Requirements

Req. No.	Description
CL-2.1	The C2 Gateway monitors the File Drop interface for the writing of new files.
CL-2.2	The C2 Gateway accepts as input the contents of text files written to the File Drop interface.
CL-2.3	The C2 Gateway moves files from the File Drop in folder to the Processed folder.
CL-2.4	The C2 Gateway detects error indications from attempts by the C2 Data Model Library to parse a message.

Table 5-9: Use Case 2 C2 Data Model Library Requirements

Req. No.	Description
CL-2.1	The C2 Data Model Library determines the protocol type of text files when the protocol type is not identified as part of the invocation of the parse function.

5.4.4 Issues

No issues have been identified for this use case.

5.5 Use Case 3 – Error Occurs in Parsing a Message

5.5.1 Use Case Description

Data received from an External Interface contains an error and cannot be successfully parsed.

5.5.2 Actions

The following Table 5-10 lists the actions performed by the actors in this use case:

Table 5-10: Use Case 3 Actions

Seq. No.	Description
3.1	The C2 Gateway receives a message from an external interface.
3.2	The C2 Gateway passes the message to the C2 Data Model Library for translation.
3.3	An error occurs when the C2 Data Model Library attempts to parse the message.
3.4	The C2 Data Model Library returns an error indication from the parse attempt.
3.5	The C2 Gateway detects the error indication.
3.6	The C2 Gateway publishes a message with an ERROR topic on the Message Bus.

5.5.3 Requirements

The following Table 5-11 lists the Requirements that were derived from the use case:

Table 5-11: Use Case 3 C2 Gateway Requirements

Req. No.	Description
CL-3.1	The C2 Gateway detects an error indication from the attempt by the C2 Data Model Library to parse a message.
CL-3.2	The C2 Gateway publishes a message with an ERROR topic on the Message Bus.

Table 5-12: Use Case 3 C2 Data Model Library Requirements

Req. No.	Description
CL-3.1	The C2 Data Model Library detects an error when it attempts to parse a message.
CL-3.2	The C2 Data Model Library returns an error indication from its parse attempt.

5.5.4 Issues

No issues have been identified for this use case.

5.6 Use Case 4 – Publish Heartbeat

5.6.1 Use Case Description

The C2 Gateway publishes a heartbeat message indicating its current status.

5.6.2 Actions

The following Table 5-13 lists the actions performed by the actors in this use case:

Table 5-13: Use Case 4 Actions

Seq. No.	Description
4.1	The C2 Gateway publishes a heartbeat message on the Message Bus indicating its current status.

5.6.3 Requirements

The following Table 5-14 lists the Requirements that were derived from the use case.

Table 5-14: Use Case 4 Gateway Requirements

Req. No.	Description
CG-4.1	The C2 Gateway publishes a heartbeat message on the Message Bus indicating that it is functioning normally.
CG-4.2	The C2 Gateway publishes a heartbeat message on the Message Bus indicating that it is in an error state.

5.6.4 Issues

The following issues represent risks that need to be addressed before the implementation can be completed.

Table 5-15: Use Case 4 Issues

ID	Issue Description
RI-2	Error states for the C2 Gateway need to be identified.

5.7 Use Case 5 – Gateway Receives a Start Command

5.7.1 Use Case Description

The Analysis System issues a Start command on the Message Bus.

5.7.2 Actions

The following Table 5-16 lists the actions performed by the actors in this use case:

Table 5-16: Use Case 5 Actions

Seq. No.	Description
5.1	The user issues a Start command via the System Management GUI.
5.2	The GUI publishes a message with a SYSTEM_CONTROL Topic and a Start sub-topic.
5.3	The C2 Gateway detects the SYSTEM_CONTROL message.
5.4	The C2 Gateway enters a state where it processes all incoming external data.

5.7.3 Requirements

The following Table 5-17 lists the Requirements that were derived from the use case:

Table 5-17: Use Case 5 C2 Gateway Requirements

Req. No.	Description
CG-5.1	The C2 Gateway has a state in which it does not process data received from external interfaces.
CG-5.2	The C2 Gateway has a state in which it does process data received from external interfaces.
CG-5.3	The C2 Gateway subscribes to messages on the Message Bus with a SYSTEM_CONTROL topic.
CG-5.4	The C2 Gateway reacts to messages on the Message Bus with a SYSTEM_CONTROL topic with a START subtopic by changing to the state in which it processes data received from an external interface.

5.7.4 Issues

No issues have been identified for this use case.

5.8 Use Case 6 – Gateway Receives a Stop Command

5.8.1 Use Case Description

The Analysis System issues a Stop command on the Message Bus.

5.8.2 Actions

The following Table 5-18 lists the actions performed by the actors in this use case:

Table 5-18: Use Case 6 Actions

Seq. No.	Description
6.1	The user issues a Stop command via the System Management GUI.
6.2	The GUI publishes a message with a SYSTEM_CONTROL Topic and a Stop sub-topic.
6.3	The C2 Gateway detects the SYSTEM_CONTROL message.
6.4	The C2 Gateway enters a state where it stops processing all incoming external data.

5.8.3 Requirements

The following Table 5-19 lists the Requirements that were derived from the use case:

Table 5-19: Use Case 6 C2 Gateway Requirements

Req. No.	Description
CG-6.1	The C2 Gateway reacts to messages on the Message Bus with a SYSTEM_CONTROL topic with a STOP subtopic by changing to the state in which it does not process data received from an external interface.

5.8.4 Issues

No issues have been identified for this use case.

5.9 Use Case 7 – Gateway Receives a Shutdown Command

5.9.1 Use Case Description

The Analysis System issues a Shutdown command on the Message Bus.

5.9.2 Actions

The following Table 5-20 lists the actions performed by the actors in this use case:

Table 5-20: Use Case 7 Actions

Seq. No.	Description
7.1	The user issues a Shutdown command via the System Management GUI.
7.2	The GUI publishes a message with a SYSTEM_CONTROL Topic and a Shutdown sub-topic.
7.3	The C2 Gateway detects the SYSTEM_CONTROL message.
7.4	The C2 Gateway shuts down.

5.9.3 Requirements

The following Table 5-21 lists the Requirements that were derived from the use case:

Table 5-21: Use Case 7 C2 Gateway Requirements

Req. No.	Description
CG-7.1	The C2 Gateway reacts to messages on the Message Bus with a SYSTEM_CONTROL topic with a Shutdown subtopic by stopping all its external interfaces.
CG-7.2	The C2 Gateway reacts to messages on the Message Bus with a SYSTEM_CONTROL topic with a Shutdown subtopic by cleaning up all resources and shutting down the gateway process.

5.9.4 Issues

No issues have been identified for this use case.

5.10 Use Case 8 – Gateway Boots Up

5.10.1 Use Case Description

The Analysis System boots up from being deactivated. As part of this action the C2 Gateway boots up.

5.10.2 Actions

The following Table 5-22 lists the actions performed by the actors in this use case:

Table 5-22: Use Case 8 Actions

Seq. No.	Description
8.1	The C2 Gateway component activates.
8.2	The C2 Gateway loads a saved list of external interfaces.
8.3	The C2 Gateway establishes an interface for each of the external interfaces in the loaded list.
8.4	The C2 Gateway enters a state where it is ready to start processing incoming data.

5.10.3 Requirements

The following Table 5-23 lists the Requirements that were derived from the use case:

Table 5-23: Use Case 8 C2 Gateway Requirements

Req. No.	Description
CG-8.1	The C2 Gateway can load a list of external interfaces.
CG-8.2	The C2 Gateway loads a list of external interfaces when it starts up.
CG-8.3	The C2 Gateway creates an external interface for each type of external interface.

5.10.4 Issues

The following issues represent risks that need to be addressed before the implementation can be completed.

Table 5-24: Use Case 8 Issues

ID	Issue Description
RI-3	If the C2 Gateway creates the external interfaces when the process starts, should it enter the Start or Stop state?

5.11 Use Case 9 – Publish Data

5.11.1 Use Case Description

The C2 Gateway publishes data upon detecting a topic published by the Planning component of the Analysis System.

5.11.2 Actions

The following Table 5-25 lists the actions performed by the actors in this use case.

Table 5-25: Use Case 9 Actions

Seq. No.	Description
9.1	The User working in the Planning GUI selects data to publish.
9.2	Planning GUI publishes data on Message Bus with the EXPORT_TO_C2 topic and the data in XML format as the message body.
9.3	The C2 Gateway sees the message and identifies the topic as one to which it subscribes.
9.4	The C2 Gateway passes the XML data to the C2 Data Model Library with the interface type for the export.
9.5	The C2 Data Model Library maps the XML to the correct output for the external interface.
9.6	The C2 Gateway publishes the mapped data to the appropriate external interface.

5.11.3 Requirements

The following tables list the Requirements that were derived from the use case.

Table 5-26: Use Case 9 Gateway Requirements

Req. No.	Description
CG-9.1	The C2 Gateway subscribes to data published on the Message Bus.
CG-9.2	The C2 Gateway processes data published on the Message Bus with the EXPORT_TO_C2 topic.
CG-9.3	The C2 Gateway publishes data to external interfaces.
CG-9.3.1	The C2 Gateway exports data to systems that use NMEA.

Req. No.	Description
CG-9.3.2	The C2 Gateway exports data to systems that use OTH-Gold.
CG-9.3.3	The C2 Gateway exports data to systems that use C-BML version 1.0.
CG-9.3.4	The C2 Gateway exports data to systems that use MSDL version 1.0.

Table 5-27: Use Case 9 Library Requirements

Req. No.	Description
CL-9.1	The C2 Data Model Library translates data from the data format internal to the Analysis System to NMEA.
CL-9.2	The C2 Data Model Library translates data from the data format internal to the Analysis System to OTH-Gold.
CL-9.3	The C2 Data Model Library translates data from the data format internal to the Analysis System to C-BML version 1.0.
CL-9.4	The C2 Data Model Library translates data from the data format internal to the Analysis System to MSDL version 1.0.

5.11.4 Issues

No issues have been identified for this use case.

5.12 Use Case 10 – User Creates an External Interface

5.12.1 Use Case Description

The user configures a new External Interface.

5.12.2 Actions

The following Table 5-28 lists the actions performed by the actors in this use case.

Table 5-28: Use Case 10 Actions

Seq. No.	Description
10.1	The user configures a new External Interface, using a list of supported External Interface types.
10.2	The GUI used by the user publishes an EXTERNAL_INTERFACE topic on the Message Bus with a New_Interface subtopic.

Seq. No.	Description
10.3	The C2 Gateway detects the EXTERNAL_INTERFACE message.
10.4	The C2 Gateway extracts the configuration information from the EXTERNAL_INTERFACE message.
10.5	The C2 Gateway creates a new interface with the attributes from the message.
10.6	The C2 Gateway adds the new external interface information to its persistent list of external interfaces.
10.7	The C2 Gateway publishes a new list of external interfaces on the Message Bus. (See Use Case 3.0.)

5.12.3 Requirements

The following Table 5-29 lists the Requirements that were derived from the use case.

Table 5-29: Use Case 10 C2 Gateway Requirements

Req. No.	Description
CG-10.1	The C2 Gateway subscribes to the EXTERNAL_INTERFACE message topic with a New_Interface subtopic.
CG-10.2	The C2 Gateway persists the list of configured external interfaces.

The requirements for creating the actual interfaces are captured in Use Case 7.

5.12.4 Issues

No issues have been identified for this use case.

5.13 Use Case 11 – User Deletes an External Interface

5.13.1 Use Case Description

The user deletes an existing External Interface.

5.13.2 Actions

The following Table 5-30 lists the actions performed by the actors in this use case.

Table 5-30: Use Case 11 Actions

Seq. No.	Description
11.1	The user views a list of existing External Interfaces and selects one to be deleted.
11.2	The GUI used by the user publishes an EXTERNAL_INTERFACE topic on the Message Bus with a Delete_Interface subtopic.
11.3	The C2 Gateway detects the EXTERNAL_INTERFACE message.
11.4	The C2 Gateway extracts the configuration information from the EXTERNAL_INTERFACE message.
11.5	The C2 Gateway deletes the existing external interface.
11.6	The C2 Gateway deletes the external interface information from its persisted list of external interfaces.
11.7	The C2 Gateway publishes an updated list of external interfaces on the Message Bus.

5.13.3 Requirements

The following Table 5-31 lists the Requirements that were derived from the use case.

Table 5-31: Use Case 11 C2 Gateway Requirements

Req. No.	Description
CG-11.1	The C2 Gateway subscribes to the EXTERNAL_INTERFACE message topic with a Delete_Interface subtopic.
CG-11.2	The C2 Gateway persists the list of configured external interfaces.
CG-11.3	The C2 Gateway deletes or deactivates an existing external interface.

5.13.4 Issues

No issues have been identified for this use case.

5.14 Use Case 12 – User Edits an External Interface

5.14.1 Use Case Description

The user edits an existing External Interface.

5.14.2 Actions

The following Table 5-32 lists the actions performed by the actors in this use case:

Table 5-32: Use Case 12 Actions

Seq. No	Description
12.1	The user views a list of existing External Interfaces and edits one.
12.2	The GUI used by the user publishes an EXTERNAL_INTERFACE topic on the Message Bus with an Update_Interface subtopic.
12.3	The C2 Gateway detects the EXTERNAL_INTERFACE message.
12.4	The C2 Gateway extracts the configuration information from the EXTERNAL_INTERFACE message.
12.5	The C2 Gateway updates the existing external interface, restarting the interface if required.
12.6	The C2 Gateway updates the external interface information in its persisted list of external interfaces.
12.7	The C2 Gateway publishes an updated list of external interfaces on the Message Bus.

5.14.3 Requirements

The following Table 5-33 lists the Requirements that were derived from the use case:

Table 5-33: Use Case 12 C2 Gateway Requirements

Req. No.	Description
CG-12.1	The C2 Gateway subscribes to the EXTERNAL_INTERFACE message topic with an Update_Interface subtopic.
CG-12.2	The C2 Gateway persists the list of configured external interfaces.

5.14.4 Issues

No issues have been identified for this use case.

5.15 Use Case 13 – Publish List of External Interfaces

5.15.1 Use Case Description

The C2 Gateway publishes a list of the defined external interfaces when it starts up.

5.15.2 Actions

The following Table 5-34 lists the actions performed by the actors in this use case.

Table 5-34: Use Case 13 Actions

Seq. No.	Description
13.1	The C2 Gateway produces a list of the configured external interfaces.
13.2	The C2 Gateway publishes the list of configured external interfaces on the Message Bus with the topic EXTERNAL_INTERFACES.
13.3	The Message Bus maintains the list of external interfaces.
13.4	The C2 Gateway checks the list of interfaces and validates it.

5.15.3 Requirements

The following Table 5-35 lists the Requirements that were derived from the use case.

Table 5-35: Use Case 13 Gateway Requirements

Req No.	Description
CG-13.1	The C2 Gateway maintains a list of External Interfaces.
CG-13.2	The C2 Gateway publishes the list of External Interfaces on the Message Bus with the topic EXTERNAL_INTERFACES.
CG-13.3	The C2 Gateway checks the list of External Interfaces.

5.15.4 Issues

The following issues represent risks that need to be addressed before the implementation can be completed.

Table 5-36: Use Case 13 Issues

ID	Issue Description
RI-4	Is the list published once when the C2 Gateway starts, or in response to a query from another component across the Message Bus?
RI-5	How is the list updated when interfaces are created or deleted? See Use Case 8 and Use Case 9.

6 TECHNICAL REQUIREMENTS

This section lists the technologies required to implement the C2 Gateway and C2 Data Model Library.

6.1 Technologies

As part of preparing this document the technologies used in existing C-BML and MSDL implementations were reviewed where that information was available. C++, C# and Java were all used for development, and no clear consensus was reached as to which language or development environment was better suited. Most tools that implement C-BML/MSDL interfaces use Web Technologies to separate the use of the standards from the language of implementation. In addition, no third party libraries have been identified that could be re-used as part of the C2 Gateway and C2 Data Model Library development.

In light of this, the following recommendations apply to the development of the C2 Gateway and C2 Data Model Library.

6.1.1 Integrated Development Environment

The Eclipse IDE will be used for development.

6.1.2 Development Language

Java will be used for development. The Java API for XML Processing (JAXP) will be used to convert objects into XML and vice versa as required.

ActiveMQ will be used to implement the Message Bus.

6.1.3 XML Editor

PSPad, an open-source text editor, is recommended for viewing and editing XML documents.

6.2 GFE/GFI

In order to achieve the objectives of this task certain elements of the solution must be provided by DRDC as government furnished equipment or information.

For each of these specifications that will be implemented, the specification will be required from DRDC:

1. OTH-Gold specification.
2. GCI++ specification.

3. CMS330 messaging specification.

6.2.1 Third Party Libraries

No Third Party Libraries had been identified at the time this document was written.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Phased Implementation

It is recommended that a phased approach be used for implementation of the C2 Gateway and the C2 Data Model Library. Incremental development will allow testing of the components throughout the development cycle as more capabilities are added. Each phase will include implementation of a testing framework, consisting of stubs and drivers to exercise the implemented code, as well as the update of a Test Plan document to include tests for the new capabilities implemented during that phase.

The exact set of features implemented will depend on the level of effort required and the amount of time available under the contract. These details will be discussed with the client directly.

The proposed phases are listed in the sections below.

7.1.1 Phase 1

Phase 1 will implement the basic capabilities of the C2 Gateway and the C2 Data Model Library.

C2 Gateway capabilities:

- Basic framework for the process, including start-up and shutdown.
- ActiveMQ Interface for publishing data.
- File Drop Interface.

C2 Data Model Library capabilities:

- Basic software library framework.
- Internal Data Model implementation.
- Import of GCI+ messages and mapping to Internal Data Model.
- Import of AIS messages and mapping to Internal Data Model.

7.1.2 Phase 2

Phase 2 will build on the capabilities from Phase 1 and add new message formats.

C2 Gateway capabilities:

- Subscription to ActiveMQ Interface for SYSTEM_CONTROL topics: Start, Stop, Shutdown.

- Generate Heartbeat.

C2 Data Model Library capabilities:

- Import of OTH-Gold messages and mapping to Internal Data Model.

7.1.3 Phase 3

The following capabilities will not be implemented under this task.

C2 Gateway capabilities:

- Subscription to Export C2 Data message.
- Configure (create, edit, delete) external interfaces.
- Persist and read external interface configuration data.
- Live interface to OTH-Gold system.
- Live interface to GCI+ system.

C2 Data Model Library capabilities:

- Export mapping of all data models.
- NMEA data model and mapping.
- Other external system data models.

APPENDIX A ADDITIONAL INFORMATION

A.1 Definitions and Acronyms

The following list identifies the acronyms and abbreviations used throughout this document:

ACO	Airspace Control Order
API	Application Program Interface
ATO	Air Tasking Orders
BML	Battle Management Language
C-BML	Coalition Battle Management Language
C2	Command and Control
C2IS	Command and Control Information Systems
C2LG	Command and Control Lexical Grammar
C2SIM	Command and Control Systems - Simulation Systems Interoperation
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAGE	Coalition Attack Guidance Experiment
CGF	Computer Generated Forces
CIG	Common Interest Group
CMS	Combat Management System
COP	Common Operating Picture
DB	Database
GCCS-M	Global C2 System-Maritime
GFE	Government Furnished Equipment
GFI	Government Furnished Information
GMU	George Mason University
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
ICC	Integrated Command and Control system
ICCRTS	International Command and Control Research and Technology Symposium
JADOCS	Joint Automated Deep Operation Coordination System
JAXP	Java API for XML Processing
JC3IEDM	Joint Consultation, Command and Control Information Exchange Data Model
JSAF	Joint Semi-Automated Force
LCSS	Land Command Support System
LDM	Logical Data Model

LVC	Live, Virtual and Constructive
MIM	MIP Information Model - Successor to JC3IEDM
MIP	Multilateral Interoperability Programme
MSDL	Military Scenario Definition Language
MSG	(NATO) Modeling and Simulation Group
NATO	North Atlantic Treaty Organization
NATO MSG-085	NATO Exercise 085
NFFI	NATO Friend or Foe Identification
NIEM	National Information Exchange Model
ODB	Operational Database
OE	Operational Environment
ORBAT	Order of Battle
OTH	Over the Horizon
REST	Representational State Transfer
SBML	Scripted BML
SICF	Système d'Information pour le Commandement des Forces
SISO	Simulation Interoperability Standards Organization
SOAP	Simple Object Access Protocol
STANAG	Standardization Agreement
STOMP	Streaming Text Oriented Messaging Protocol
TIP	Technical Information Package
TTCP	The Technical Cooperation Program
UAV	Unmanned Aerial Vehicle
VBS	Virtual Battlespace
WISE	Widely Integrated Systems Environment
XML	Extensible Markup Language