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Design and Evaluation of the MINTACS SeeTrack Exchange (MINSTE) Concept Demonstrator

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ABSTRACT

MINSTE is a computer program that automates data exchange between MINTACS (MINe Warfare TACtical Software) used by the RAN for planning and assessment of naval mine countermeasures (MCM) and SeeTrack, a 'generic' mission planner and post–mission analysis tool for unmanned underwater systems – particularly towed or self-propelled side-scan sonar that images underwater objects. MINSTE was developed by DSTO with open-source software in order to reduce operator overheads by automating data entry for reported mine-like objects, which can amount to several hundred contacts for some MCM missions. This document describes the MINSTE concept design and development within the context of current and emerging RAN requirements for mine warfare mission planning and reporting in network-enabled and joint operations. For a more detailed discussion on the installation and use of MINSTE, the reader is referred to DSTO-TN-0887, "User Guide for MINTACS SeeTrack Exchange (MINSTE)".

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Executive Summary

MINTACS – the MINe Warfare Tactical Software developed for the Royal Australian Navy (RAN) – supports the Mine Warfare Force Commander and operations staff with mission planning, task monitoring, and detailed assessment of mission progress by individual assets or force elements. MINTACS also contains database and charting tools for the management and visualisation of tactical data such as mines and q-routes. MINTACS is primarily designed for mine countermeasures operations conducted by dedicated, manned platforms, like the Mine Hunter Coastal (MHC) vessels.

As part of Project SEA1778, the RAN is acquiring unmanned systems (UMS) to conduct military operations such as reconnaissance of sea routes for the detection of mine-like objects. Commercial UMS are generally supported by their own mission planning and post-mission analysis software. One such tool used by DSTO and the RAN is SeeByte's SeeTrack. SeeTrack is advertised as being a 'generic' mission planner and battlespace visualisation tool for operations that may involve several different types of UMS. An example of its 'generic' capability is a module for analysing UMS side scan sonar imagery, which has the ability to ingest several different standard sonar data formats. It is envisaged that in the near future, a tool like SeeTrack will be used to analyse sonar imagery for detection of mine-like contacts, and report these contacts up the chain of command. The contacts would then archive into a common MCM repository like MINTACS for further analysis. It was from this reporting requirement that the concept demonstrator MINTACS SeeTrack Exchange (MINSTE) evolved. The primary purpose of MINSTE is to automate the exchange of contact data from SeeTrack to MINTACS.

MINTACS Release 12, currently in use by the RAN, is designed for manual data entry of tactical mine objects and environmental contacts. This process is acceptable for conventional mine hunting clearance where contacts are addressed one at a time, but unwieldy for unmanned operations, where several hundred mine-like contacts can be reported in one mission. The US MCM tactical decision aid MEDAL automates contact reporting by requiring all MCM UMS to generate messages in MEDAL-compatible formats, a strategy suitable for all nations that have MEDAL, namely, the United States. A more suitable approach for multi-national coalition operations may be to report in a common format. One such format is the NATO standard MCMREP used for conventional manned operations, but ongoing MEDAL software development has adopted the use of XML files. XML is a general purpose open-source specification to facilitate the sharing of structured data across different information systems.

The SEA1778 Project S&T Plan included a work package to de-risk software integration issues through the development and demonstration of a prototype software interface "for data transfer between UMS and mine warfare command support system." Although originally slated for outsourcing, the research was a natural progression of DSTO work conducted during Trial MONGOOSE 07 and the RAN Fleet Training Activity DUGONG 07, and the result, MINSTE, was demonstrated to the RAN MCDFEG during a meeting of the Tactical Development Steering Group in May 2008.

MINSTE is considered a concept demonstrator, because instead of following the usual tendency of developing a purpose-built (and therefore single-use) tool for data exchange, it was developed to take advantage of existing standard data formats, particularly human-readable text-based XML, to support automated data exchange. In order to further test requirements for extensibility and interoperability, MINSTE follows the principles of object-oriented programming, and is developed entirely from Java open-source software, which is designed to run on any computer platform.

While the primary objective of MINSTE was to facilitate development requirements for software integration and interoperability between various mission planning and reporting tools currently on the market, the feedback DSTO has received from the RAN on MINSTE went much further than this, suggesting new concepts of operation, not only for unmanned systems, but also for MINTACS and the Mine Warfare Command Support System.

An accompanying CDROM is attached to end of this report containing the described software and DSTO-TN-0887: User Guide for MINTACS SeeTrack Exchange (MINSTE).

Contents

Glossary

API	Application Programming Interface
ATSL	Approved Technical Standards List
AUSCDT	Australia Clearance Diving Team
CDT	Clearance Diving Team
COI	Community Of Interest
COIN	Common Operating Interface for Navy
COMATG	COMmander Amphibious Task Group
COP	Common Operating Picture
CRN	Contact Reference Number
DoD	US Department of Defense
DSTO	Defence Science Technology Organisation
EODMU1	Explosive Ordnance Disposal Mobile Unit ONE
EXI	Efficient XML Interchange
FTA	Fleet Training Activity
GIS	Geographical Information System
GUI	Graphical User Interface
HQ	HeadQuarters
HTML	Hyper-Text Markup Lanuguage
JAXB	Java Architecture for XML Binding
JDBC	Java DataBase Connectivity
JDBC-ODBC	Java DataBase Connectivity-Open DataBase Connectivity
JDK	Java Development Kit
JRE	Java Runtime Environment
JTA	Joint Technical Architecture
JVM	Java Virtual Machine
MCDFEG	Mine warfare and Clearance Diving Force Element Group
MCD OSU	Mine warfare and Clearance Diving Operations Support Unit
MCDTG	Mine warfare and Clearance Diving Task Group
MCM	Mine CounterMeasures
MCMREP	MCM Report (message format)
MCMTA	Mine CounterMeasures Tasking Authority
MEDAL	Mine warfare Environmental Decision Aid Library

MHC	Mine Hunter Coastal
MINSTE	MINTACS SeeTrack Exchange
MINTACS	MINe warfare TActical Command Software
MRN	Mine Reference Number
MS	MicroSoft
MTO	Maritime Tactical Operation
MW	Mine Warfare
MWCSS	Mine Warfare Command Support System
MWDC	Mine Warfare Data Centre
NATO	North Atlantic Treaty Organisation
NEO	Network-enabled operations
OIC	Officer-In-Charge
OOP	Object-Oriented Programming
PMA	Post-Mission Analysis
RAN	Royal Australian Navy
REA	Rapid Environmental Assessment
RIMPAC	RIM of the PACific
RSDB	Route Survey Database
SfS	Solutions from Silicon
SOA	Service Oriented Architecture
SQL	Structured Query Language
TACDEV	TACtical DEVelopment
TRM	Technical Reference Model
TTCP	The Technical Cooperation Panel
UMS	Unmanned Systems
URL	Uniform Resource Locator
UUV	Unmanned Underwater Vehicle
VSW	Very Shallow Water
W3C	World Wide Web Consortium
XML	eXtensible Mark-up Language

1. Introduction

Two new concepts of operations for Mine Warfare (MW) and Mine Countermeasures (MCM) are used with (1) underwater unmanned systems (UUVs), and (2) principles of network-enabled (or "net centric") operations (NEO) and interoperability. UUVs are being used for MCM as a way to remove service personnel from the minefield in what are typically considered "dull, dirty and dangerous" missions. A primary objective of NEO is rapid and effective data collection and communication in near real-time. However, current limitations in maritime communications, particularly underwater technologies, means that data collected by UUVs are generally processed after the mission is completed (that is, during post-mission analysis or 'PMA'). Hence, in a case such as this, a practical application of NEO is to ensure that data from PMA is reported up the command chain quickly and is interoperable with other suites of software used by command headquarters. Project SEA 1778 has been established for the acquisition of new technologies to support these concepts.

During 2007, DSTO attend three trial activities where these new concepts were tested: EX MULGOGGER 07, Trial MONGOOSE 07 and FTA DUGONG 07.

At EX MULGOGGER 07, DSTO was requested to analyse the rapid and effective reporting of environmental and contact data between Australia Clearance Diving Team Headquarters (AUSCDT HQ) and the Amphibious Task Group Command (COMATG). A tactical development (TACDEV) objective was to investigate the use of MINTACS as a common operating picture (COP) tool – using it to import and chart data collected by Australian Clearance Diving Teams (AUSCDT) during Maritime Tactical Operations (MTO)[1]. DSTO observations at MULGOGGER were summarised in an informal minute, which noted interoperability issues between MINTACS and ArcGIS[2] as well as difficulties with the use of MINTACS as a COP tool. The main issue was that MINTACS required all data, including reported contacts, to be entered manually, and that the typical map resolution of MINTACS was too coarse for proper display of AUSCDT search areas.

MONGOOSE 2007 was a TTCP[3] MAR TP-13 (Mine Warfare) trial run held during AUVFest, Panama City, FL (USA). The two MONGOOSE objectives were: (1) to examine MCM mission planning requirements for multiple unmanned systems and (2) to generate a COP from the data they collected. Using the MW tactical decision aids, MINTACS from Australia and MEDAL from the US, the collection and archiving of data from several unrelated systems was tested along with operational planning and assessment of the MCM capability. Interoperability between MINTACS and MEDAL was examined by testing automatic transfer of data on mine-like contacts in MEDAL to MINTACS[4]. At the request of the SEA 1778 sponsor, interoperability between SeeTrack (used for UUV mission planning and post-mission

[1] MTO is generally used to refer to remote and/or clandestine operations typically conducted by AUSCDTs.
[2] ArcGIS is an integrated collection of GIS software products. URL - http://www.esri.com/
[3] The Technical Cooperation Program (TTCP) is an international organisation that collaborates in defence scientific and technical information exchange; program harmonisation and alignment; and shared research activities for the five nations: Australia, Canada, New Zealand, UK and US.
[4] Contact data was exchanged between MEDAL and MINTACS R12 using NATO structured Mine Countermeasure Report (MCMREP). This was achieved by a MINTACS R12 add-on developed by SfS.

analysis) and MINTACS was also analysed. An important outcome from MONGOOSE was an understanding of the gaps in the exchange of data between SeeTrack and MINTACS: it was evident that contact data from UUV missions processed using SeeTrack could only be imported into MINTACS by manual data entry, resulting in significant overheads to operator workload.

The Fleet Training Activity FTA DUGONG 07 was the first exercise where the RAN MCDFEG tasked unmanned systems to search areas for mine-like contacts. DSTO attended FTA DUGONG 07 to benchmark MCM data exchange, with MINTACS being used as the ultimate repository for the data collection and reporting, as well as MCM operations analysis. DSTO objectives for DUGONG were to benchmark data exchange between existing deployable (portable) sonar systems and MINTACS or ArcGIS software. MINTACS, which was used to generate the COP, required contact data to be imported with the classification 'POSSIBLE MINE.' Whilst a suite of MS Excel macros had been written prior to the exercise to help support automated data exchange, existing compatibility issues necessitated manual data entry and added data formatting.

As a result of the trials the MINTACS SeeTrack Exchange (MINSTE) was developed as a concept demonstrator to meet the requirements for a network enabled, interoperable software application that provides quick and seamless information flow between the UMS PMA software tool, SeeTrack and the MW command support tool MINTACS R12, through the use of standards developed for Internet-based data exchange and computer programs for cross-platform applications.

This report aims to provide greater insight into MINSTE design principles.

2. Background

2.1 Observations from DUGONG 07

The DSTO Mine Warfare Systems Group attended DUGONG 07 to observe on-site data collection and analysis, and to benchmark data exchange between MCM units, the MCM Tasking Authority (MCMTA), and the COMATG [1].

One area of focus was to examine MCM data exchange between the four software packages used by the MCD Operations Support Unit (OSU) for PMA – SeeTrack Military, SeaScan PC Review, EdgeTech Discover and C-Max MaxView – and the tactical decision aid MINTACS, used by the MCMTA.

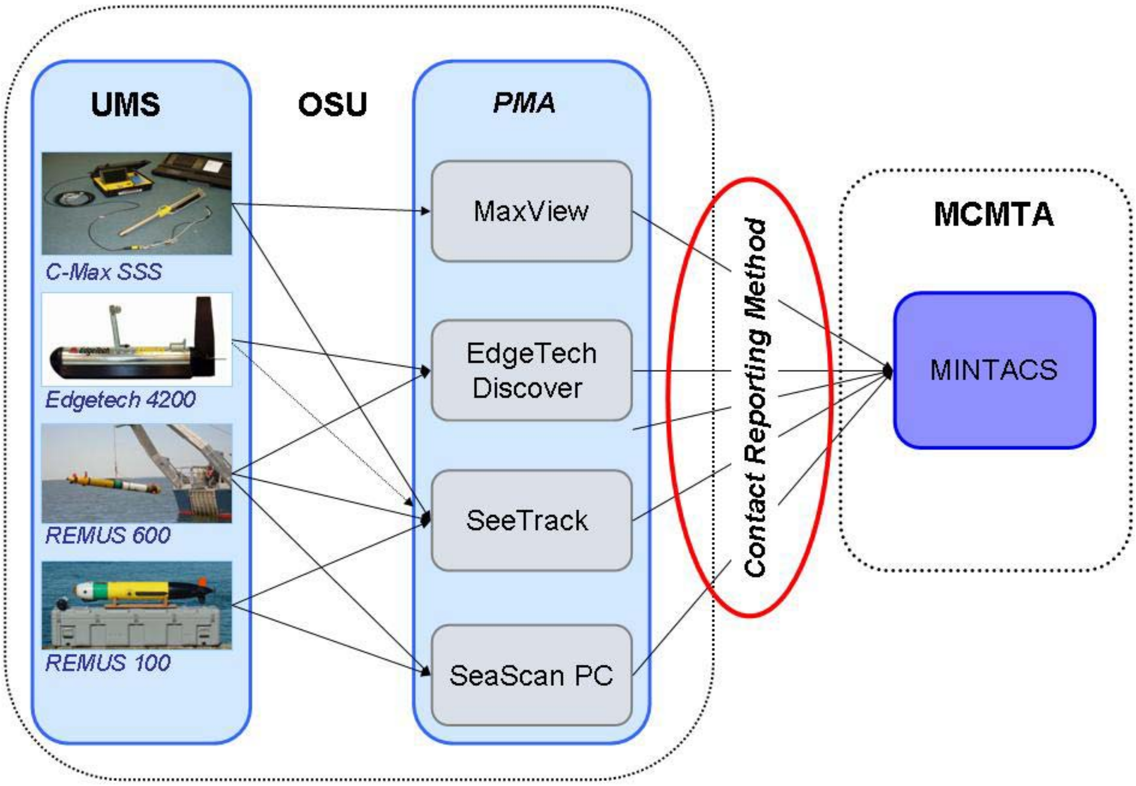

Figure 1: Overview of contact reporting at DUGONG 07. UMS sonar records are processed for contacts by some form of PMA software, the output of which is then reported to the MCMTA

An objective at DUGONG 07 was to import any contact data reported by OSU and classified as *POSSIBLE MINE* into MINTACS. There were 4 unmanned systems[5] used at DUGONG with an array of options to conduct PMA of the data collected by these systems. The software used for PMA generated contact reports with differing data types and data output. Data types reported by the PMA software would differ, for example, by contact location latitudes and longitudes being reported in degree minutes or decimal degrees, or by time formats ranging from epoch time, Julian or Zulu time. Some PMA tools allow measurement and reporting of contact dimensions, while others do not.[6] There were no procedures on how to reference contacts (*e.g.*, a standard Contact Reference Number), so the labelling of reported contacts was left to the discretion of the operator conducting PMA,[7] and the PMA output took various forms, as text files, Excel files or HTML files.

[5] The four UMS at DUGONG 07 were: C-Max SSS, EdgeTech 4200, REMUS 600 and REMUS 100.
[6] For instance, Sea Scan PC Review only reported the height of the contact; MaxView did not report any measurements while Discover and SeeTrack reported height, width and length measurements.
[7] This is in contrast to existing doctrine and Standard Operating Procedures.

Only contacts classified as POSSIBLE MINE were imported into MINTACS. While this practice limited the number of contacts reported, the difficulty of manually entering contact data into MINTACS was increased by the need to also fill in any gaps in the data reported, filter out unnecessary data, convert to appropriate units and reformat the data according to MINTACS requirements.

A MINTACS operator can input contact data by hand (commonly referred to as 'hand-jamming') or through the 'Import Contact' functionality in MINTACS, using correctly-formatted Excel spreadsheets. Both methods involve 'tweaking' of the data, such as reformatting the latitude longitude formats from degree minutes to decimal degrees and date times into a MINTACS date/time format. Furthermore, both methods could lead to data entry errors and loss of traceability. Although use of an Excel spreadsheet and the creation of specific macros could reformat large amounts of data quickly, this still involves an operator knowing what macro to use and how to format the specific piece of data. In addition, the 'Import Contact' wizard available in MINTACS involves dealing with each contact individually, which could prove time consuming.[8]

Interoperability issues between the PMA software and MINTACS was first flagged at MONGOOSE 2007 where transfer of contact data reported by SeeTrack to MINTACS was tested.[9] At MONGOOSE, the focus was on using the 'Import Contact' functionality in MINTACS, whereby the data was reformatted using an Excel spreadsheet. From this, the need to develop Excel macros to reformat this data, and the gaps in the data exchange between SeeTrack and MINTACS became clear. At DUGONG, the Excel macros were applied to the SeeTrack data files but there was still a need to 'tweak' the data, and it became evident that there was a need for a common referencing system to track the contact from SeeTrack to MINTACS. In addition, other Excel macros had to be written to deal with the output of other PMA software, such as SeaScan PC or EdgeTech Discover.

It is apparent from these observations that even simple data transfer between MINTACS and SeeTrack was at best an involved process and one that could be significantly improved by a purpose-built user interface. DSTO reported on these observations onsite at DUGONG and, based on this analysis, was invited to participate in Exercise Rim of the Pacific 2008 (RIMPAC 08). It was anticipated that at RIMPAC 08 several UUVs would be used, and there would be a requirement to import the contact data into MINTACS. The need for easy importation of contact data into MINTACS drove the rapid development of a software interface to automatically transfer data from one PMA application, namely SeeTrack, to MINTACS.

[8] For instance, one reported mission had 24 contacts.
[9] MONGOOSE 07 was the first time data exchange between SeeTrack and MINTACS was tested by DSTO. Data exchange between the two applications had been demonstrated at a trial held in Australia, April 2007.

2.2 Software Tools

2.2.1 MINTACS R12

The Mine Warfare Tactical Command Software (MINTACS) is a MW tactical decision aid developed by Solutions from Silicon (SfS) and in use by the RAN and UK Royal Navy (MINTACS R13). It is a comprehensive Tactical Command software suite that enables the "Mine Warfare Force Commander and operations staff to plan missions, monitor tasking and conduct detailed assessment of mission progress from an individual asset or total force perspective" [2].

2.2.2 SeeTrack Military

SeeByte SeeTrack is a "generic" UUV mission planning and battlespace visualisation tool. It acts as a viewer and analysis software for side scan sonar imagery. The side scan sonar imagery can be viewed and processed where contacts are identified and stored to the SeeTrack database [3].

3. MINSTE Overview

The MINSTE application provides a means to transfer data automatically from SeeTrack to MINTACS, and move data from one MINTACS database to another.

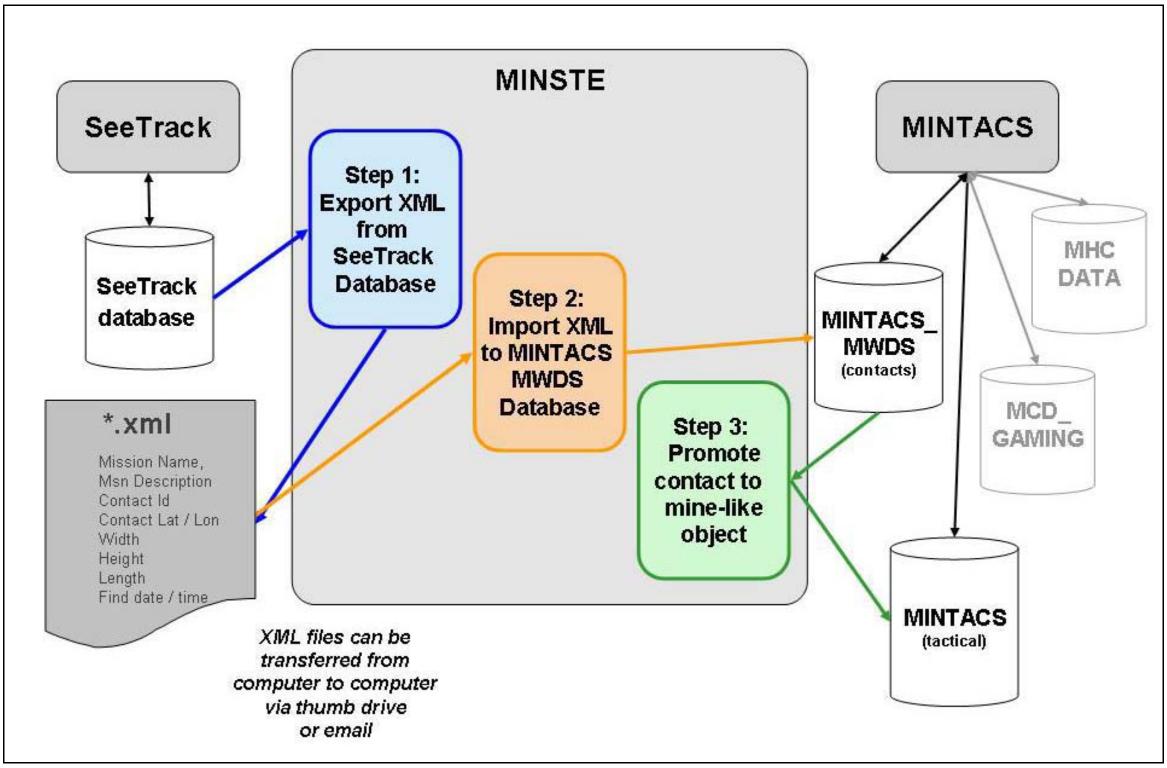

Figure 2: Functional view of the MINSTE application

XML is used as the standard to enable information processing and interoperability between SeeTrack and MINTACS R12. XML is license free, platform independent and a well supported method for putting structured data in a text file.[10] XML was chosen as the standard for data transfer between SeeTrack and MINTACS for several reasons:

- In operations, these applications will likely reside on different computers that, for security reasons, may have an 'air gap,' that is, they are not networked, and data must be transferred via a data storage device like a compact disk or USB memory
- XML files are text-based and human-readable, thus allowing "on site" security checks
- XML is being proposed as a standard for data transfer within the US military and other government agencies.

MINSTE interfaces directly to the SeeTrack database and the MINTACS databases. MINSTE queries the SeeTrack database on the mission selected by the user, and exports the contact data associated with the selected mission to a text file where each data element is tagged from an XML schema developed for this purpose. Then MINSTE processes the XML file, and each tagged element is imported into the appropriate table and fields contained within the MINTACS Route Survey Database (RSDB).

MINTACS treats contacts as environmental data, and possible mines as tactical objects, and there is a separate database for each. As with contact data, tactical features like POSSIBLE MINES must be entered manually in MINTACS R12. Hence, for convenience, a 'Promote Contact' function was added to MINSTE to allow transfer of data between the MINTACS RSDB and tactical databases. There are no XML files generated or used for this functionality as the movement of data is done between databases contained within the MINTACS application (and so no "air gap" required) and the databases being located in the same SQL Server Group (and so no transfer of data across different systems).

MINSTE requires configuration to create connections to the databases used by SeeTrack and/or MINTACS. Connection to the MS Access database used by SeeTrack requires the MINSTE user to select the appropriate database. For MINSTE to connect to the MINTACS databases 'MINTACS' and 'MINTACS_MWDS,'[11] the user must input the values for MS SQL Server 2000 settings.

In summary, this release of MINSTE provides three functions:

1. Export data from SeeTrack database to an XML file.
2. Import XML file into the MINTACS RSDB – MINTACS_MWDS.
3. Promote a contact from the MINTACS RSDB (MINTACS_MWDS) to the MINTACS Tactical Display Database (MINTACS).

[10] For more information on XML refer to Section 4.3.2 XML and Section 5 XML for Data Exchange

[11] MINTACS database stores the tactical for each operation while the MINTACS_MWDS is the route survey database, managed by the MW Data Centre as HMAS Waterhen.

4. MINSTE Design

4.1 Operator Workload

The main thrust for the development of the MINSTE application was to reduce the workload of the MINTACS operator. Manual entry of contact data generated by SeeTrack and other PMA software into MINTACS can be cumbersome and prone to error. Providing a means to automate processing of contact data not only reduces manual data entry but also allows for timely, accurate information to be available to the MW Commander.

Data transfer is achieved through a Graphical User Interface (GUI) that presents the user with a series of five windows, each denoting one step of the process, where the user can make selections from the information provided by simple button pressing. First, MINSTE reads the SeeTrack database and provides the operator with a list of missions to select from. Once the mission is selected all the contacts associated with the mission are outputted directly to a XML file, the name of which can be designated by the user in a second window, with a third window confirming generation of the XML file. This or other XML files can then be selected by the operator in a fourth window, and clicking the "Import XML to MINTACS" button will insert all contact data for a mission into the MINTACS RSDB. This information is then available for viewing in the MINTACS application.

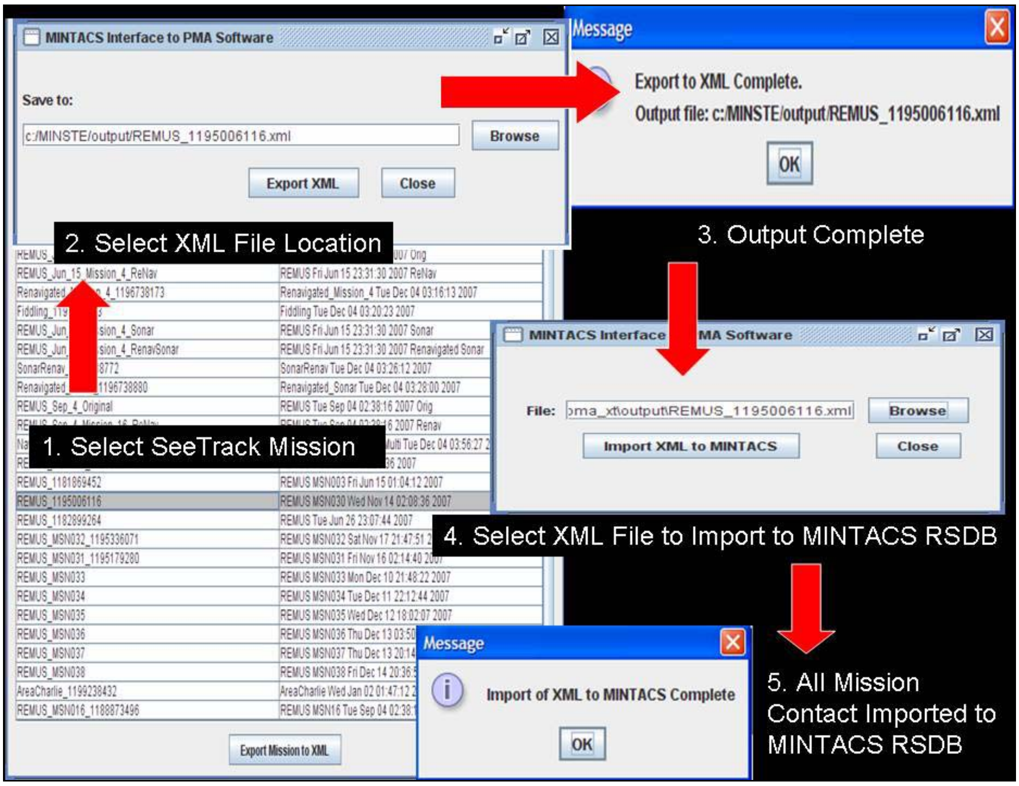

Figure 3: Example of button selections required and required operator interaction to export contact data from the SeeTrack database to an XML file and import that XML file to the MINTACS RSDB

MINSTE was demonstrated to LEUT Brandon Horn, Staff Officer Tactical Development MCD, by transferring 24 contacts from one DUGONG 07 mission from the SeeTrack database to MINTACS. His response was: "You did in a few minutes what used to take 45."

While 45 minutes may seem excessive, it could be expected, given that MINTACS is not designed to support UUV MCM operations. For example, manual data entry was purpose-built into MINTACS, probably to encourage careful deliberation of data viability. While this is appropriate for MHC minehunting operations, where generally only contacts with a high likelihood of being mines are reported, it is not feasible for typical UUV operations, which can result in several hundred contacts being reported at a time. While MINTACS can manage route survey contact data, it is not designed to do so simultaneously with minehunting (hence the separate databases), whereas UUV operations can be considered a combination of the two. To be fair, at one time MINTACS actually did support automated data transfer via MCMREPS, but subsequently lost this functionality following changes to communications software and protocols. Hence, in some regard, MINSTE can be considered a software "patch" to update MINTACS functionality.[12] Nevertheless, the noted time savings of some 45 minutes indicates that this utility will aid in the rapid and seamless transfer of data during high tempo operations, with a "few clicks of the button."

4.2 Information Security

The use of XML allows for transparency and information assurance when exchanging data between two separate pieces of software. MINSTE could have been designed to simply extract the required data from the SeeTrack database and store the data within the MINSTE program as a binary file and then populate the MINSTE databases. However, this process would allow for little transparency and no ability to insert an air gap between two possible classified database systems.

XML is a good way to overcome such security considerations as it generates a text-based data file that is both machine- and human-readable. Since the data exchanged can be checked for information assurance by both humans and automated systems, it precludes the possibility that MINSTE could be used or mistaken for "spyware."

```
<object>
  <contactID>28308</contactID>
  <latitude>-33.0210378398674</latitude>
  <longitude>137.747353486466</longitude>
  <width>1.41844616223701</width>
  <length>1.18130717824099</length>
  <height>0.423372804262136</height>
  <timeDate>2007-11-14T13:25:52.000+11:00</timeDate>
</object>
```

Figure 4: Example of XML output from one SeeTrack mission, illustrating the ease with which XML files can be read. XML tags provide a reference for each data element.

[12] Indeed, SfS have noted that much of MINSTE's functionality is available in new releases of MINTACS.

4.3 Technology

4.3.1 Java

The MINSTE software is programmed in Java. Java was developed by Sun Microsystems, with Java applications typically compiled to byte code that can run on any Java virtual machine (JVM) regardless of computer architecture. That is, MINSTE can be installed and run on any platform (Intel/Windows, Mac/Jaguar, Sun/Unix) as long as the Java Runtime Environment (JRE) is installed.

The JRE is the software required to run any application deployed on the Java Platform. End-users commonly use a JRE in software packages. For developers, Sun also distributes a superset of the JRE called the Java 2 Standard Development Kit (JDK), which includes development tools such as the Java compiler and debugger.

4.3.2 XML

The MINSTE application writes out and reads in XML documents. XML is a general purpose specification that allows users to define their own "schema" to tag data elements. Its primary purpose is to facilitate the sharing of structured data across systems. XML simplifies data sharing of incompatible formats by converting the data to plain text.

4.3.3 Java Architecture for XML Binding (JAXB)

A Java application importing or exporting data to XML can use a free application programming interface (API) named Java Architecture for XML Binding (JAXB) [4]. JAXB will bind Java code to the XML schema. It provides the necessary code to write out Java objects to an XML file based on this schema (marshalling) and create Java objects bases on an XML file (unmarshalling).

NetBeans 6.0[13] provides tooling support for JAXB, principally by means of a wizard that turns various types of XML documents into Java classes [5].

4.3.4 Java Database Connectivity (JDBC)

MINSTE application communicates with the databases of SeeTrack and MINTACS using a Java Database Connectivity (JDBC) API [6] that defines how a database will be accessed.

Specific drivers are required to connect the application to each database. SeeTrack uses MS Access, and MINSTE connects to this database using JDBC-ODBC Driver released by Sun. MINTACS uses MS SQL Server 2000 or MS SQL Server 7. MINSTE will communicate automatically to MS SQL Server 2000 once the MS SQL Server settings are configured within the MINSTE program. This is possible by using a Microsoft released SQL Server driver for JDBC.

[13] Netbeans 6.0 was used as the development environment for MINSTE.

5. XML for Data Exchange

5.1 XML

XML is a fundamental enabler for the automated exchange of data and the processes that act upon that data. It is a method for putting structured data in a text file along with describing, archiving and communicating digital information in a text file. It is displayed and defines its data content by the use of tags (word bracketed by ‘<’ and ‘>’) and attributes.


```xml
<missionName>REMUS_1195006116</missionName>
  <missionDescription>REMUS MSN030 Wed Nov 14 02:08:36
     2007</missionDescription>
<object>
  <contactID>28307</contactID>
  <latitude>-33.021017079916</latitude>
  <longitude>137.747327465382</longitude>
  <width>0.0</width>
  <length>1.10537960931011</length>
  <height>0.428375641494789</height>
  <timeDate>2007-11-14T13:23:23.000+11:00</timeDate>

     </object>
```


Figure 5: Example of a mission and contact data from a SeeTrack XML output file. Each piece of information is given on one line, tagged by a description of the data content and the attribute value.

Each XML line in the file makes it clear to an extraction routine, such as in MINSTE or human reader, what the data between the tags mean.

For MINSTE, DSTO developed an XML schema to specify the data that is transferred from SeeTrack to MINTACS, and its format. This schema was developed to be as generic as possible and incorporates a data set that is common amongst the PMA software. The XML schema is attached as Appendix A.

In summary, the benefits of XML are:

- XML incorporates modern commercial best practice such as robust tool sets and platform independence.
- The software industry understands the need for a common information exchange resulting in XML being available in most commercial-off-the-shelf (COTS) products. This provides a basis for implementing interoperability across application, vendor and organisation boundaries.
- XML uses a text based protocol, so it is both man- and machine-readable, problems can be fixed by a simple text editor, and there are no proprietary message formats.

Whilst XML is designed for large scale information storage, processing and exchange its shortcomings are quickly identified when the XML data is required to be transmitted across network protocols. By its nature XML is verbose and this verbosity clogs networks. It is possible to compress XML files, using compression tools such as gzip[14] or XMill[15] but this compression comes at a processing and time cost, however, general purpose compression may not be adequate in all environments. Also XML is resource intensive; the XML needs to be parsed by the application and due to its textual make-up subsequently increases processing time. This in itself needs to be addressed due to the use of smaller, hand-held and/or mobile devices where battery consumption needs to be efficiently managed.

Binary XML formats are being developed to overcome these shortcomings along with the clear advantage that can be gained with interoperable systems through the use of XML. One format in particular, EXI – Efficient XML Interchange[16] was developed initially by a company named AgileDelta[17], and is now being standardised and endorsed by the World Wide Web Consortium (W3C). EXI is an emerging standard where work is being carried out by W3C's XML Binary Characterisation (XBC)[18] and EXI Working Groups[19]. It is a serialisation format for XML to optimise performance and the utilisation of computational resources with the end goal to reduce the impact of XML application interoperability.

An additional disadvantage for the use of XML is that a user group or community of interest (COI) needs to be established to agree on a common XML schema and maintain the standard. A COI would ensure that the schema developed for data exchange considers all required elements. So, for example, an MCM COI may require an XML standard that not only supports MINTACS and UUV PMA software, but also MUCS, AMEAS, geospatial information systems for the ADF and other Australian government agencies (*e.g.*, the Bureau of Meteorology), and coalition partners such as the US and NATO.[20]

5.2 Mandated Standards for Interoperability

A key objective of MINSTE is to demonstrate interoperability between two systems that are identified as enablers in MCM mission performance. For systems to be interoperable they require adherence to a set of technical standards that mandate the means by which systems interface and exchange data.

To achieve seamless integration, an architectural framework or Technical Reference Model (TRM) may be used to endorse and mandate standards to achieve interoperability. The US Department of Defense (DoD) Joint Technical Architecture (JTA) Volume 1 [7] consists of core

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[14] URL – http://www.gzip.org
[15] Efficient compressor for XML; URL – http://www.liefke.com/hartmut/xmill/xmill.html
[16] Efficient XML Interchange (EXI) Format 1.0 September 2008: URL - http://www.w3.org/TR/2008/WD-exi-20080919/
[17] Information about AgileDelta and Efficient XML can be found at: URL - http://www.agiledelta.com/product_efx.html
[18] URL - http://www.w3.org/TR/xbc-properties/
[19] URL - http://www.w3.org/XML/EXI/
[20] The USN uses the MCM tactical decision aid MEDAL, which has its own XML schema. The NATO standard tactical decision aid is MCMExpert.

standards applicable to all US DoD systems.[21] Its purpose is to provide a common conceptual framework and a common vocabulary so that the diverse components within an enterprise can better coordinate acquisition, development and support US DoD information technology. The JTA mandates the use of XML [8] for document or information exchange.

While Australia, at present, does not have an endorsed TRM, it does have an Approved Technology Standards List (ATSL) [9] managed by the Australian Department of Defence Chief Information Officer Group. The ATSL references the US DoD JTA and provides a set of categories for use in Defence acquisition and development with focus being on interoperability [10]. It details its recommendations and lists XML as a standard for data exchange, stating:

> Data exchange services enable data-level interoperability (the ability of two or more systems to effectively exchange data) by exchanging data: without loss of attributes (e.g. both Excel data and the formula); in an agreed format (syntax); in a manner in which the data meaning is interpreted in the same way (semantics); and via an agreed common set of configuration profiles to support the exchange of data…With the increasing use of the Internet and Intranets, mark-up languages have recently proliferated for various communities of interest (COI). In particular, the adoption of XML and its developments is becoming more widespread. [11]

5.3 Net-Centric Concept and Web Services

The basis for net-centricity is to allow an organisation to enhance its information position and capabilities of its decision makers. The net-centric approach moves technology away from an application-centric to a data-centric paradigm, where an information environment is provided that is comprised of interoperable computing and communication components. The incorporation of UMS into the MCM environment will enable the automatic transfer of information between components in this environment – with contact data being the first step – resulting in better situational awareness and efficient decision making.

Net-centric environments are underpinned by a range of standards and technologies including component based systems, Service Oriented Architecture (SOA), middleware and frameworks. SOA "make software resources available and discoverable as services to end-user applications and other services through public or published interfaces…. Currently, the most common technology used to realise SOAs are Web Services". [12]

The web services paradigm provides a solution for the movement away from the monolithic software that currently exists to a communicable service that is platform independent (that is, based on Internet protocols).

[21] The US Department of Defense has migrated to a new model called the Net Centric Operations and Warfare (NCOW) Reference Model [US DoD 2006] which not only mandates the us of XML but also other web based standards. While the US DoD no longer references the JTA TRM, it does retain the JTA as a useful source of standards – both mature and emerging for interoperability purposes. More information about the NCOW Reference Model refer to URL - http://asks.dau.mil/dag/Guidebook/IG_c7.2.6.1.asp

Web services are described as "distributed services that are identified by URLs, whose interfaces and binding can be defined, described and discovered by XML artefacts, and that support direct XML message-based interactions with other software applications via internet-based protocols." [13]

Whilst MINSTE is not a web service, as a concept demonstrator, it provides an example of how web service technologies that are available today will allow for the development of software applications used for information management by the MCDFEG.[22] [1]

Web services exhibit communication properties; they follow a message-driven operational model exchanging messages in XML syntax. MINSTE demonstrates this ability by managing the data exchange between SeeTrack and MINTACS using XML.

In addition, the web service paradigm undertakes to provide service-centric computing by using the Internet as the platform; that is, services are delivered over the Internet (or the Intranet). To achieve this, MINSTE was developed and implemented using the platform independent language Java. Whilst the MINSTE software architecture acts as an interface and not a distributed computing solution, the use of Java allows the ability for MINSTE to be extended to provide this functionality.

6. Software Engineering Principles

6.1 Reusability, Maintainability and Object-Oriented Programming

The software programming design of MINSTE takes on an object-oriented programming (OOP) approach. OOP is the standard way of most software design today. It has many benefits including maintainability and reusability. MINSTE was designed to be maintainable by mapping the objects to the XML schema. Therefore, when new elements are added to the XML schema, this change can be incorporated easily into the Java code. The software design also ensures the code is reusable and extendable, ensuring the easy integration of new PMA software as part of the interface.

The main focus for MINSTE development was that the application be easily extended in the future. With additional PMA software tools being incorporated into the interface, new components can easily be integrated into the current software.

6.2 Economy, Flexibility and the Java Development Environment

Developing MINSTE in Java allows MINSTE to be run on a wide range of computer systems without expensive and time consuming code rewrites or compilations. It also allows access to

[22] Additional information outlining the reasons why the MCDFEG should adopt web services can be found in the DSTO Client Report MCM Data Exchange at DUGONG 07: Quick-Look Report (U), DSTO-CR-2008-0035.

a wide range of good open source libraries and packages and the possibility of using the tool through a web-based service.

The NetBeans Integrated Development Environment Version 6.0 was used for the development of MINSTE. This is an open source software tool and available for download from http://www.netbeans.org/.

6.3 Open Source Tools

- Netbeans Integrated Development Environment (IDE): http://www.netbeans.org/
- To install Netbeans with JAXB functionality install the 'All' download version: http://download.netbeans.org/netbeans/6.1/final/
- Java Architecture for XML Binding (JAXB) : http://java.sun.com/developer/technicalArticles/WebServices/jaxb/
- Java Runtime Environment (JRE) 6.0: http://java.sun.com/javase/downloads/?intcmp=1281
- JDBC: http://java.sun.com/javase/6/docs/technotes/guides/jdbc/
- Microsoft SQL Server JDBC Driver: http://www.microsoft.com/downloads/details.aspx?FamilyID=c47053eb-3b64-4794-950d-81e1ec91c1ba&DisplayLang=en

7. Other Comments

7.1 Development Effort

MINSTE contains 34 classes with approximately 2500 code lines[23].

The original S&T work plan for de-risking Project 1778 allocated $150k for contractor development. DSTO developed MINSTE from its conception through to the software design, implementation, testing and documentation, for approximately $12k with 0.3 staff years' salary. Costings

- Attendance at trial, DUGONG07 – $6000
- MINSTE development for one S&T 3 staff member - $3000
- MINSTE installation packaging, one S&T 3 staff member - $1000
- Publication of one MINSTE User Manual and Technical Note – $500
- Skills development for one S&T staff member – $1500

The tool was developed without any requisition costs, using only open-source software.

[23] Refer to Irwin, A. (2009) *User Guide for MINTACS SeeTrack Exchange (MINSTE)*, DSTO-TN-0887 for a complete schematic MINSTE class diagram and software developer notes.

7.2 User Feedback

Throughout its development, the MINSTE concept was presented to the MCDFEG for user feedback and input into the design and use of the application. Discussions with the MCDFEG also extended to the use of MINTACS R12 as a data management tool and Geographic Information System (GIS) for information reported from the UMS to the tasking or command HQ. Below are some opinions voiced during presentations of the use of XML for data exchange and demonstration and use of the MINSTE application.

MINSTE was demonstrated to Mr Wayne Dunn, OIC of the MWDC HMAS Waterhen, on the 11 April 2008. A number of points were discussed at this meeting:

- *Requirement to keep the MINSTE GUI simple*. This was achieved by providing simple function selections and instructions to guide the user through the complete import / export process.
- *Requirement by the MWDC for an interface between MINTACS and PMA tools for deployable side-scan sonar systems*. Mr Wayne Dunn suggested that a complete software interface be developed as proposed in the S&T Plan SEA 1778 Work Package 6 – Analysis of MWCSS Interfaces.
- *Requirement for a standard operating procedure within the RAN on reporting environmental contacts and possible mines (tactical features) from deployable systems*. This point was raised because the contact referencing system has been hard-coded into MINSTE, since the only existing standard for contact referencing (to align with MINTACS R12 requirements) only supports the circumstance when a contact is promoted to a tactical mine object. In this case, mine object is referenced by an 'Asset Call Sign' and a user-selected mine reference number (an 'MRN' as opposed to a 'CRN').

An overview of MINSTE and its objectives as a concept demonstrator was presented to the MCD Group Tactical Development Steering Group, 2 May 2008. LCDR Andrew Fraser, OIC Operations Support Unit, sent the following comments in an email dated 9 May 2008:

- MINSTE, as a concept demonstrator and interface tool, needed no more development.
- S&T research should be conducted to further investigate more powerful and purpose-built tools for Rapid Environmental Analysis (REA) data analysis (such as ArcGIS). It was suggested that it may be more beneficial to develop software interfaces to these other tools rather than to MINTACS, which is designed specifically for MW mission planning and assessment.
- Future MINTACS upgrades should focus on improving MCM mission planning, assessment and force analysis. Future requirements for MINTACS development could include provision for a common user interface to a MCM 'toolbox' which would include mission planning for unmanned systems.
- LCDR Fraser commented that by making available on the Defence Secret Network a suite of data analysis tools, such as ArcGIS products:

> *"…represents a great opportunity for the bringing together of a COP [common operational picture] for the disparate warfare disciplines/environments…This will allow MINTACS to be operated alongside a powerful COP/GIS with potentially seamless transition /exchange of data between them…MCM utopia!"*

A copy of the MINSTE application was provided to LEUT Lena Thompson, Maritime Geospatial Officer – Meteorology and Oceanography, for use at RIMPAC 08. LEUT Thompson was deployed to work with the UUV Operators of Explosive Ordnance Disposal Mobile Unit ONE (EODMU1) of the US Navy. At RIMPAC 08, hundreds of contacts generated over the three weeks of UUV operations were managed and processed using the Common Operating Interface for Navy (COIN), which is basically the US version of SeeTrack Military[24]. MINSTE was used to import contact data from COIN (SeeTrack) to MINTACS, and the process was reported to be streamlined and incident free. LEUT Thompson made comment on a few operational issues with the use of MINSTE and MINTACS R12 for the UUV missions conducted at RIMPAC 08.

These issues included:

- There were a large number of contacts generated in SeeTrack that were imported into MINTACS using the MINSTE interface and XML files. When the contacts were in the MINTACS database, issues with assigned contact classification were noted. PMA conducted by EODMU1 would, at the very least, assign contact classification in COIN; however when the contact data was imported into MINTACS the contact classification was assigned "POSSIBLE MINE". MINSTE assigns "POSSIBLE MINE" classification automatically and does not capture this extra classification information from the COIN (SeeTrack) database. Consequently, this classification data was lost in the data exchange.
- Management of contact data was difficult within MINTACS. All contact data was rendered in the GIS, regardless of operation, and in the "management of contacts" window, every contact in the database was displayed. As mentioned, with hundreds of contacts being reported this was difficult to manage.
- The MINSTE application was not installed on the deployed DSN because the software had not been tested to determine if it met the requirements for installation on the Defence network environment. The application was used only on a standalone laptop with an installed version of MINTACS R12 while the SeeTrack database was copied to an external hard drive for access. As a result, MINSTE could not provide effective support to the Operations Staff through rapid transfer of contact data from the PMA software used at RIMPAC to the MINTACS SQL Server.

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[24] COIN is the US Navy version of SeeTrack Military and is tightly integrated with the US tactical decision aid MEDAL. A US Government developed interface sits between SeeTrack and MEDAL providing sophisticated exchange of information between the two systems.

The results of the RIMPAC 08 exercise and the real issue of managing a large number of reported contacts from many UMS can be summarised in a comment sort from CMDR Dean Shopen, Commander Australian Mine Warfare and Clearance Diving Task Group:

> "*The Mine Warfare and Clearance Diving Task Group (MCDTG) executed command of the Undersea MCM Task Group at Exercise RIMPAC over the period 29 Jun - 01 Aug 08, in Hawaii. The Task Group consisted on 146 personnel from 5 different countries (US, UK, Canada, the Netherlands and Australia), with 9 UUV's and 4 dolphins. The MCDTG staff experienced considerable difficulty in achieving transparent and accurate transfer of contact information from each Task Unit (represented by the different participating countries), because they operated their organic data management systems.*
>
> *This resulted in large volumes of contacts being manually collated into MINTACS because there was no effective common data interface. The status of the contacts could not be edited from the results of progressive VSW MCM missions, which added to the complexity of the cumbersome arrangement. Compatibility of data management systems needs to occur at the lowest level in order to capture all contact details and allow information sharing at the lowest sub-system level.*
>
> *The current arrangement used by the USN with the interoperability between COIN and MEDAL illustrates a baseline of compatibility that needs to be achieved by MINTACS if the RAN aspires to effectively contribute to a coalition VSW MCM force. This baseline requirement should also be supplemented with contemporary, smart image store and representation capacity. Based on the information provided by DSTO the MINSTE interface demonstrating the use of XML has potential to provide the capability required for an effective MCM data management system.*"

8. Conclusion

MINSTE was developed to demonstrate the following concepts:

1. Rapid data transfer between MCM mission support tools,
2. Use of human- and machine-readable XML as a standard for data exchange,
3. Automated management of contact data within MINTACS,
4. Use of object-oriented programming principles and platform-independent languages for command support software.

MINSTE was successful in that it achieved its original objectives to reduce operator overheads associated with Mine Warfare (MW) data management, and to familiarise MW personnel with the advantages of using common data standards and flexible programming techniques.[25] Because much of the functionality demonstrated by MINSTE will be incorporated in later versions of MINTACS, no further development of MINSTE is planned.

One significant outcome from the development of MINSTE is an awareness of the advantages for the adoption of a standard architecture framework underpinned by interoperability standards and net-centric concepts. In particular, Service Oriented Architecture (SOA) has become the leading approach and becoming more common place in the commercial world. SOA software is available and discoverable as a service and marks a transformation from isolated software environments to a more dynamic and interactive one. The use of such technology is the acknowledgement of commercial vendors of the need to move their software components from monolithic applications to those that are communicable and integrated at minimum cost. The most common technology to realise SOAs are web-based services whose benefits include being platform independent (for example, based on Internet Protocols) and using XML to conduct the interactions between the software applications. XML is a robust tool set and enabler for information exchange providing interoperability and platform independence.

Consideration should now be sort for further MCM data exchange analysis at the semantic level. Semantic interoperability is where the system or computer processing the data received is able to extract knowledge from that data. Interoperability between systems not only requires a technical understanding between the systems but also requires an understanding of the information and context received. A semantic interoperability analysis is a future possibility in understanding the role and meaning of the data being communicated from the UMS PMA to the MCM tactical decision aid (and possibly other GIS tools).

[25] Indeed, one user suggested that exchange of operational data may well be supported by two standards: XML for transfer of tactical data, and Additional Military Layers (AMLs), which are designed for the transfer of large amounts of data and imagery produced by persistent sensors.

A number of methods can be adopted for a semantic interoperability analysis. One is defining the ontology of the system being used. Ontologies are a formal representation of a set of concepts within a domain and the relationship between the concepts. It is possible to then extend semantic interoperability to the tactical decision aid domain or even a web (IP) domain. This can be achieved by using a Semantic Web framework. Semantic Web is the next-generation of web concepts, where concepts rather than keywords are linked within the (internet) domain. Languages are now available, at varying degrees of development, that enable this linkage of concepts to occur. One such language is the Resource Description Framework (RDF) that graphs concepts to concepts in a semantic network. The RDF can be easily mapped and managed in an XML file format, where for example, Java requires an open-source API to achieve this.

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Appendix A: XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>

<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
            targetNamespace="http://xml.netbeans.org/schema/MissionReport"
            xmlns:tns="http://xml.netbeans.org/schema/MissionReport"
            elementFormDefault="qualified">

        <xsd:element name="exportmission">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element                            name="missionName"
type="xsd:string"></xsd:element>
                <xsd:element                     name="missionDescription"
type="xsd:string"></xsd:element>
                <xsd:element          name="object"          minOccurs="0"
maxOccurs="unbounded">
                    <xsd:complexType>
                        <xsd:sequence>
                            <xsd:element                  name="contactID"
type="xsd:integer"></xsd:element>
                            <xsd:element                   name="latitude"
type="xsd:double"></xsd:element>
                            <xsd:element                  name="longitude"
type="xsd:double"></xsd:element>
                            <xsd:element                      name="width"
type="xsd:double"></xsd:element>
                            <xsd:element                     name="length"
type="xsd:double"></xsd:element>
                            <xsd:element                     name="height"
type="xsd:double"></xsd:element>
                            <xsd:element                   name="timeDate"
type="xsd:dateTime"></xsd:element>
                        </xsd:sequence>
                    </xsd:complexType>
                </xsd:element>
            </xsd:sequence>
            <xsd:attribute name="missionID" type="xsd:int"/>
        </xsd:complexType>
    </xsd:element>

</xsd:schema>
```

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Automatic data exchange, XML, MINTACS, SeeTrack, UUV

19. ABSTRACT
MINSTE is a computer program that automates data exchange between MINTACS (MINe Warfare TACtical Software) used by the RAN for planning and assessment of naval mine countermeasures (MCM) and SeeTrack, a 'generic' mission planner and post-mission analysis tool for unmanned underwater systems - particularly towed or self-propelled side-scan sonar that images underwater objects. MINSTE was developed by DSTO with open-source software in order to reduce operator overheads by automating data entry for reported mine-like objects, which can amount to several hundred contacts for some MCM missions. This document describes the MINSTE concept design and development within the context of current and emerging RAN requirements for mine warfare mission planning and reporting in network-enabled and joint operations. For a more detailed discussion on the installation and use of MINSTE, the reader is referred to DSTO-TN-0887, "User Guide for MINTACS SeeTrack Exchange (MINSTE)".