

Modifications and Validation of the ADSS SAR-AIS Pipeline and IA Pro for Ship Detection

Technical report to close out GEOINT Task 13

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1 INTRODUCTION

The “Research and development support for SAR-based GEOINT and terrain analysis” contract (W7714-091140/001/SV), initiated in December 2011, aims to provide research and development (R&D) technical support for the Space and ISR Applications (SIA) Section at Defence Research and Development Canada – Ottawa (DRDC Ottawa).

The work for Task 13 was carried out between April 2013 and December 2013. The objectives for Task 13 were to modify the DRDC Ottawa ADSS-based SAR-AIS Association pipeline, ADSS modules, CSIAPS, and Image Analyst Pro (IA Pro) for multi-sensor applications and analysis of SAR and AIS data. Task 13 consists of four subtasks:

- Modification of Image Analyst Pro (IA Pro);
- Modification of the ADSS SAR-AIS Association pipeline;
- Implement geospatial database and Import/Export tools for AIS data. The objective is to implement a geospatial database for storing vector data, and to develop tools to import and export AIS data to the geospatial database; and,
- Analysis of SAR and AIS data.

Section 2.1 contains a list of items in Task 13’s Statement of Work, and their completion status. Section 2.2 contains a list of Task 13 items that were completed, and a brief description of each item. Incomplete items are explained in Section 3.

2 TASK ITEMS, DESCRIPTIONS, AND THEIR STATUS

2.1 Task Items and Their Status

Table 1 lists all subtask items of Task 13 and their completion status. Further to this information, every completed item is described in greater detail in Section 2.2.

Table 1: List of Task 13 items and their completion status

Item Number	Item	Complete	Incomplete
Subtask 1: Modification of Image Analyst Pro			
1.1	<ul style="list-style-type: none"> • Develop drivers for: <ul style="list-style-type: none"> ○ Unclassified and classified imagery; and, ○ Unclassified and classified detected vector files. 	✓	
1.2	<ul style="list-style-type: none"> • Ingest linked vector files and imagery data from the output vector file of the SAR-AIS pipeline 		✓
1.3	<ul style="list-style-type: none"> • Implement a Graphical User Interface for the locally convex hull software tool (if feasible) 	✓	
1.4	<ul style="list-style-type: none"> • Evaluation and implement (if feasible) ship detection and ship wake detection algorithms (algorithms to be provided by the Scientific Authority) 		✓
1.5	<ul style="list-style-type: none"> • Modify interactive vector validation tool (IVVT): <ul style="list-style-type: none"> ○ Accommodate additional detection sources ○ Improve reporting method (e.g., Polar Epsilon reporting method) 	✓	
1.6	<ul style="list-style-type: none"> • Contribute to technical reports. 	✓	
Subtask 2: Modification of the ADSS SAR-AIS Association pipeline			
2.1	<ul style="list-style-type: none"> • Integrate DRDC ADSS capabilities with DSTO (classified and unclassified) capabilities: <ul style="list-style-type: none"> ○ Support integration; and, ○ Regression testing. 	✓	
2.2	<ul style="list-style-type: none"> • Modify or implement, if needed, new ADSS modules to accommodate various imagery, detection, and non-detection sources (classified and unclassified) 		✓

Item Number	Item	Complete	Incomplete
2.3	<ul style="list-style-type: none"> Provide SAR-AIS pipeline demo and support distribution of the pipeline via a single virtual machine to DRDC Ottawa clients/partners, as needed 	✓	
2.4	<ul style="list-style-type: none"> Upgrade the current CDL 9 pipeline to CDL10, with additional capabilities 	✓	
2.5	<ul style="list-style-type: none"> Modify the locally convex hull (automation, more data, speed, etc.) software tool 	✓	
2.6	<ul style="list-style-type: none"> Contribute to SAR-AIS Association technical reports 	✓	
2.7	<ul style="list-style-type: none"> Attend Hercules2 project meetings in support of, or on behalf of, DRDC, as required. Some VTCs may require scheduling outside of normal business hours 	✓	
Subtask 3: Implement geospatial database and Import/Export tools for AIS data. The objective is to implement a geospatial database for storing vector data, and to develop tools to import and export AIS data to the geospatial database			
3.1	<ul style="list-style-type: none"> Develop an IA Pro or ADSS tool to read AIS data and write relevant information to the geospatial database, and a tool (IA Pro, ADSS, maybe CSIAPS) to search for and export AIS data from the geospatial database 	✓	
3.2	<ul style="list-style-type: none"> Extract ship information from the internet ships register (e.g., CANMARNET) based on MMSI and archive using the geospatial database for later retrieval 	✓	
Subtask 4: Analysis of SAR and AIS data			
4.1	<ul style="list-style-type: none"> Analyze acquired SAR and AIS data using DRDC Ottawa custom tools, and summarize the detection statistics 	✓	

2.2 Descriptions of Completed Task Items

Table 2 contains brief description for each completed item of Task 13.

Table 2: Completed items and descriptions

Item Number	Item Description
Subtask 1: Modification of Image Analyst Pro	
1.1	<ul style="list-style-type: none"> • Develop drivers for: <ul style="list-style-type: none"> ○ Unclassified and classified imagery; and, ○ Unclassified and classified detected vector files. <p>Implemented SICD driver for point target analysis and azimuth shift calculation. More testing is needed.</p>
1.3	<ul style="list-style-type: none"> • Implement a Graphical User Interface for the locally convex hull (LoCoH) software tool (if feasible) <p>Implemented a Graphical User Interface for LoCoH (see Figure 1), which allows user to select start and end dates, enter parameters such as Area of Interest and Cluster Proximity. The ability was also added to load and save configuration files.</p>
1.5	<ul style="list-style-type: none"> • Modify interactive vector validation tool (IVVT): <ul style="list-style-type: none"> ○ Accommodate additional detection sources; and, ○ Improve reporting method (e.g., Polar Epsilon reporting method). <p>IVVT was modified to accommodate additional detection sources, and its reporting method was improved based on Polar Epsilon's reporting method. This allows our image analyst to load IVVT output directly into Excel for statistical analysis.</p>
1.6	<ul style="list-style-type: none"> • Contribute to technical reports. <p>IA Pro's modifications and tool development have been documented in monthly reports and in PowerPoint slide decks during technical meetings.</p>

Item Number	Item Description
Subtask 2: Modification of the ADSS SAR-AIS Association pipeline	
2.1	<ul style="list-style-type: none"> • Integrate DRDC ADSS capabilities with DSTO (classified and unclassified) capabilities: <ul style="list-style-type: none"> ○ Support integration; and, ○ Regression testing. <p>Integration was carried out starting August 2013 after new version of ADSS (Ubuntu 12.04 OS) was received from DSTO. Both ADSS and ADSS_DRDC code were validated, merged, and tested. Compiler errors and conflicts were resolved.</p> <p>Regression testing was then performed on standard SAR-AIS datasets to make sure the new ADSS produce identical results.</p>
2.2	<ul style="list-style-type: none"> • Modify or implement, if needed, new ADSS modules to accommodate various imagery, detection, and non-detection sources (classified and unclassified) <p>Several ADSS_DRDC modules were modified because the dependency library syntax had been changed in the new version (e.g., track angle calculation in the RSAT-2 driver).</p> <p>A number of modifications were made to ADSS modules in order to accommodate various imagery, improve results, and fix bugs. These modifications include, but are not limited to: provide more interpolation modes for ship positioning, better band scaling in KML, error check when OceanSuite detections go out of bounds, prevent erroneous horizontal lines in land mask generation.</p> <p>DRDC modifications to ADSS code were saved as modules in the ADSS_DRDC repository, because DSTO was reluctant to accept/integrate them into the main ADSS build, with another major upgrade pending.</p>
2.3	<ul style="list-style-type: none"> • Provide SAR-AIS pipeline demo and support distribution of the pipeline via a single virtual machine to DRDC Ottawa clients/partners, as needed <p>The updated SAR-AIS pipeline, via a single virtual machine, has been installed at DRDC Ottawa and demonstrated to the DRDC SA. Technical support has been provided to DRDC Ottawa clients/partners, such as out-of-bounds error handling when OceanSuite detections fall slightly outside the image bounds.</p>
2.4	<ul style="list-style-type: none"> • Upgrade the current CDL 9 pipeline to CDL10, with additional capabilities <p>The CDL 9 pipeline has been upgraded to CDL10 with all the newly added capabilities.</p>
2.5	<ul style="list-style-type: none"> • Modify the locally convex hull (automation, more data, speed, etc.) software tool <p>The locally convex hull algorithm was re-implemented in C++ for speed and for compatibility with ADSS. The Computational Geometry Algorithms Library (CGAL) (www.cgal.org) was used in the data thinning and the nearest neighbour search of the convex hull algorithm. The newly developed GUI with configuration files provides users with automation and more control.</p> <p>The modified LoCoH tool demonstrated significantly improved performance over its original R script.</p>

Item Number	Item Description
2.6	<ul style="list-style-type: none"> Contribute to SAR-AIS Association technical reports <p>Provided standard operating procedures of SAR-AIS Association System and contributed to its technical documentations.</p>
2.7	<ul style="list-style-type: none"> Attend Hercules2 project meetings in support of, or on behalf of, DRDC, as required. Some VTCs may require scheduling outside of normal business hours <p>Attended a number of Hercules project meetings initiated by DRDC.</p>
<p>Subtask 3: Implement geospatial database and Import/Export tools for AIS data. The objective is to implement a geospatial database for storing vector data, and to develop tools to import and export AIS data to the geospatial database</p>	
3.1	<ul style="list-style-type: none"> Develop an IA Pro or ADSS tool to read AIS data and write relevant information to the geospatial database, and a tool (IA Pro, ADSS, maybe CSIAPS) to search for and export AIS data from the geospatial database <p>An AIS database has been implemented using Microsoft SQL Server. The database consists of two main tables: one for AIS position reports (messages 1 to 4, 11, 18 to 19) and another for AIS static voyage data (messages 5, 24). The two tables can be cross-referenced with a SQL query in order to get both position and static data.</p> <p>A standalone application was written, using the open source “AIS parser” library, to read NMEA messages, reconstitute multi-part messages, and update the database. This command line tool is written in Java, so that its code can be easily integrated with CSIAPS’ geospatial data repository component.</p> <p>The “Open Database” tool in IA Pro can be used to connect to this AIS database and extract position reports into IA Pro (see Figure 2). A custom function was built on the database side, with an interface in IA Pro, in order to execute a common query: return the AIS contact closest to a given date and time for each MMSI within a time boundary. This enables users to easily obtain AIS data closer to the image acquisition time.</p>
3.2	<ul style="list-style-type: none"> Extract ship information from the internet ships register (e.g., CANMARNET) based on MMSI and archive using the geospatial database for later retrieval <p>This was completed; for details, see Item 3.1.</p>
<p>Subtask 4: Analysis of SAR and AIS data</p>	
4.1	<ul style="list-style-type: none"> Analyze acquired SAR and AIS data using DRDC Ottawa custom tools, and summarize the detection statistics <p>Analyzed various RADARSAT-2 mode data (FQ, SCNB, SCWA, and MSSR DVWF and OSVN) over the Davis Strait and Norwegian Sea using OceanSuite. Saved the results in OTH Gold format for associating OceanSuite ship detections with exactView-1 AIS data.</p> <p>Processed and analyzed concurrent SAR and AIS data using OceanSuite, SAR-AIS ADSS Pipeline, and IA Pro over New Zealand using various RADARSAT-2 beam mode data (F0W, SCNB, and MSSR DVWF and OSVN). Compiled detection statistics and reported results in tables for the above analyses.</p>

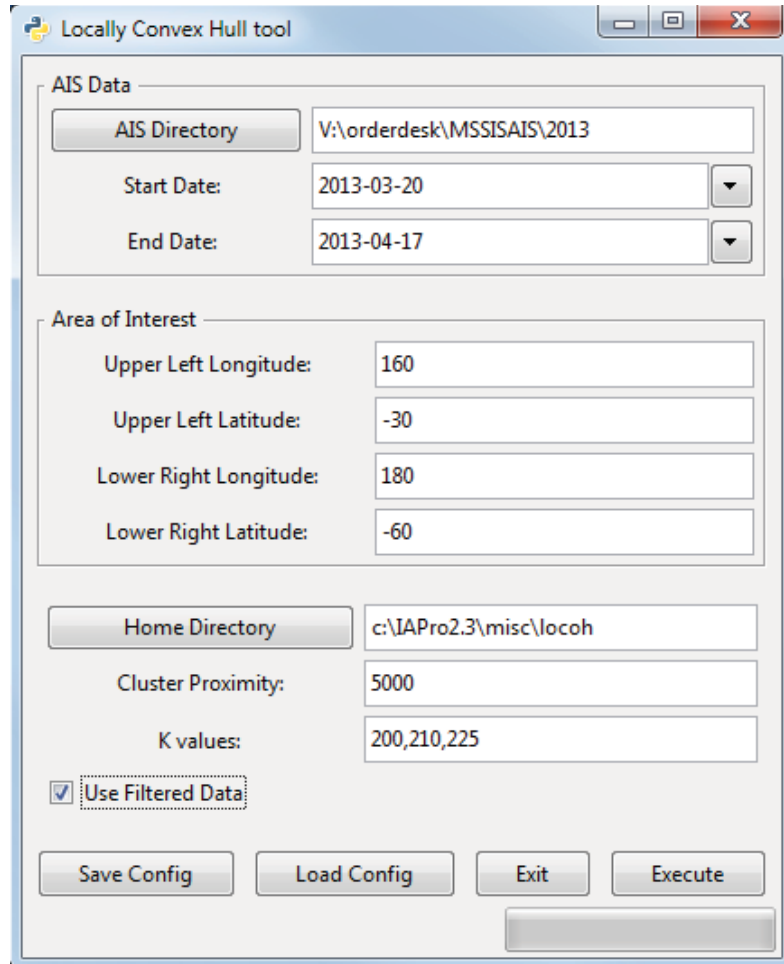


Figure 1: IA Pro's GUI for the Locally Convex Hull tool

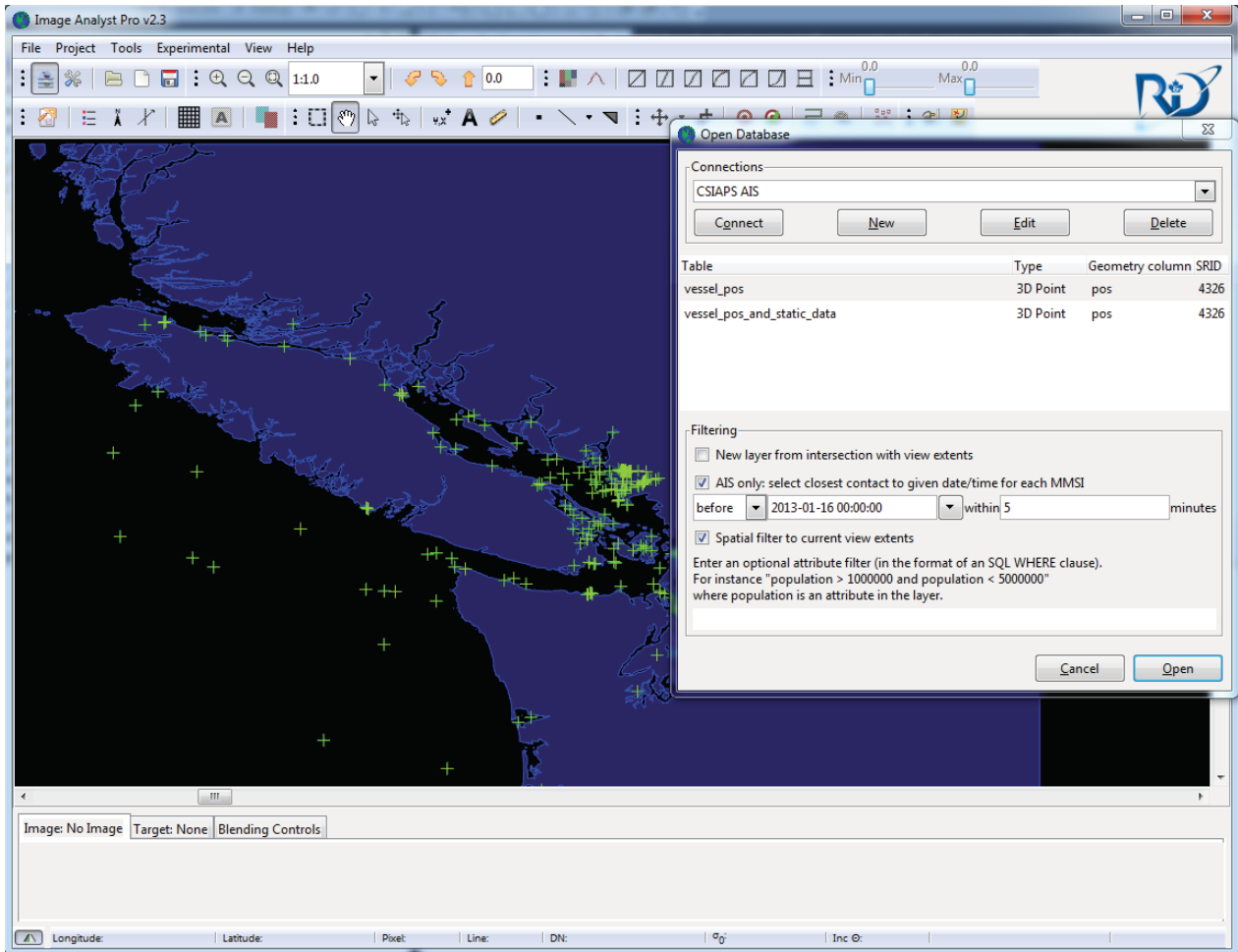


Figure 2: IA Pro’s Open Database tool, used to read and display AIS data from the database

3 EXPLANATIONS OF INCOMPLETE TASK ITEMS

There are two items that were not completed in Task 13. They were a result of DRDC redirecting more resources to higher priority tasks than was originally planned. The status for each incomplete item is given in Table 3.

Table 3: Incomplete items' current status

Item Number	Item	Status
1.2	Ingest linked vector files and imagery data from the output vector file of the SAR-AIS pipeline	This item is half done. ADSS CDL stream has been modified to pass linked vector files and imagery data onto IA Pro. Now we need to add GUI support in IA Pro to allow user to view the linked data and select which to ingest/display.
1.4	Evaluation and implement (if feasible) ship detection and ship wake detection algorithms (algorithms to be provided by the Scientific Authority)	A quick evaluation of OceanSuite was performed, and reported how the fuzzy logic ship detection algorithms were done in OceanSuite. Actual implementation will be carried out in future. Ship wake detection algorithm implement will be carried out in future.