

SAR-AIS Association System Upgrade and Support

Technical report to close out GEOINT Task 17

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Contract Report

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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 17 was carried out between October 2013 and March 2014. The objectives for Task 17 were to modify the DRDC Ottawa SAR-AIS Association System, which entails development of and modifications to ADSS modules and Image Analyst Pro (IA Pro). Task 17 consists of three subtasks:

- Modification of Image Analyst Pro;
- Modification of the ADSS SAR-AIS Association pipeline; and,
- Analysis of SAR and AIS data.

Section 2.1 contains a list of items in Task 17’s Statement of Work, and their completion status. Section 2.2 contains a list of Task 17 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 17 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 17 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"> Test SICD driver and upgrade as required 		✓
1.2	<ul style="list-style-type: none"> Port the DRDC-developed OceanSuite ship detection algorithm into IA Pro 		✓
1.3	<ul style="list-style-type: none"> Propose way ahead to port the DRDC-developed RedBox ship wake analysis algorithm into IA Pro 	✓	
1.4	<ul style="list-style-type: none"> Upgrade the Interactive Vector Validation Tool (IVVT): <ul style="list-style-type: none"> Support several SAR detectors in addition to OceanSuite including SDA and the DRDC-developed Likelihood Ratio Test; Retain AIS data provenance (i.e., the data source) 	✓	
1.5	<ul style="list-style-type: none"> Upgrade the OTHGold output format to match that of the SAR-AIS Association pipeline 	✓	
1.6	<ul style="list-style-type: none"> Upgrade the geospatial database interface to improve database searches by implementing a graphical SQL query builder (similar to IVVT thresholds) that is pre-populated with the available sensors and default thresholds 		✓
1.7	<ul style="list-style-type: none"> Conduct requirements capture for geospatial database upgrade (e.g., more fields in the AIS table, same message for multiple sources, etc.), discuss options with SA, and implement 		✓
1.8	<ul style="list-style-type: none"> Stitch contiguous image frames to facilitate display 		✓
1.9	<ul style="list-style-type: none"> Contribute to technical reports 	✓	

Item Number	Item	Complete	Incomplete
Subtask 2: Modification of the ADSS SAR-AIS Association pipeline			
2.1	<ul style="list-style-type: none"> Implement a module to pre-sort global AIS data to AOI and time in advance of association pipeline run 		✓
2.2	<ul style="list-style-type: none"> Extract ship information from an authoritative ship database (e.g., internet ships register on CANMARNET or a database to be provided by MSOC) based on MMSI and populate output message with ship identification, ship characteristics, and information provenance 		✓
2.3	<ul style="list-style-type: none"> Test compatibility with new AIS and SAR data sources and upgrade drivers as required 		✓
2.4	<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 	✓	
2.5	<ul style="list-style-type: none"> Contribute to technical reports 	✓	
2.6	<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: Analysis of SAR and AIS data			
3.1	<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 17.

Table 2: Completed items and descriptions

Item Number	Item Description
Subtask 1: Modification of Image Analyst Pro	
1.3	<ul style="list-style-type: none"> • Propose way ahead to port the DRDC-developed RedBox ship wake analysis algorithm into IA Pro <p>A previously developed ship wake analysis tool (RedBox) was evaluated to determine if any work is reusable. It was found that the tool did not produce good results due to various design limitations. However, some of the mathematical derivations (such as the Radon transform of the Fourier transform) may be useful. It was concluded that a new ship wake detection algorithm should be developed.</p> <p>Literary research was conducted to evaluate the use of both the Radon transform and the matched filter for ship wake detection. Preliminary investigations of these methods were conducted using Matlab. It was found that these methods had different advantages and disadvantages. An algorithm combining both the Radon transform and the matched filter was therefore proposed.</p> <p>The proposed algorithm was tested on a RADARSAT-2 Extended Low (EL1) image over Gibraltar with 20 ships selected manually. Of these 20 ships, 18 had wakes that were correctly detected while two wakes were incorrectly detected (see Figure 1).</p> <p>The proposed algorithm is currently being migrated into C++ and added as an IA Pro tool. It allows the user to input the ship position in geodetic coordinates (latitude and longitude) as well as the ship's maximal speed.</p>
1.4	<ul style="list-style-type: none"> • Upgrade the Interactive Vector Validation Tool (IVVT): <ul style="list-style-type: none"> ○ Support several SAR detectors in addition to OceanSuite including SDA and the DRDC-developed Likelihood Ratio Test; ○ Retain AIS data provenance (i.e., the data source) <p>The OTHGold GDAL driver was upgraded to ingest messages from other SAR ship detectors, such as Ship Detection Algorithms (SDA).</p> <p>The SAR-AIS Association pipeline (specifically the NMEA driver) was enhanced to produce a tag in the detection to specify the AIS data source (live exactEarth, exactEarth ftp or MSSIS). This field can be viewed in IA Pro's Interactive Vector Validation Tool.</p>
1.5	<ul style="list-style-type: none"> • Upgrade the OTHGold output format to match that of the SAR-AIS Association pipeline <p>The IVVT has an option to save its results in OTHGold format. This option has been upgraded to match the format that the SAR-AIS Association pipeline produces.</p>

Item Number	Item Description
1.9	<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>
Subtask 2: Modification of the ADSS SAR-AIS Association pipeline	
2.4	<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 to filter out rogue PGHP lines in exactView-1 AIS data.</p>
2.5	<ul style="list-style-type: none"> Contribute to technical reports <p>Provided standard operating procedures of SAR-AIS Association System and contributed to its technical documentations.</p>
2.6	<ul style="list-style-type: none"> Attend Hercules-2 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-2 project meetings initiated by DRDC.</p>
Subtask 3: Analysis of SAR and AIS data	
3.1	<ul style="list-style-type: none"> Analyze acquired SAR and AIS data using DRDC Ottawa custom tools, and summarize the detection statistics <p>Processed and analyzed concurrent SAR and AIS data using OceanSuite, SAR-AIS ADSS Pipeline, and IA Pro over the Spratly Islands using RADARSAT-2 MSSR beam mode data. Compiled detection statistics and reported results in tables for the above analyses.</p>

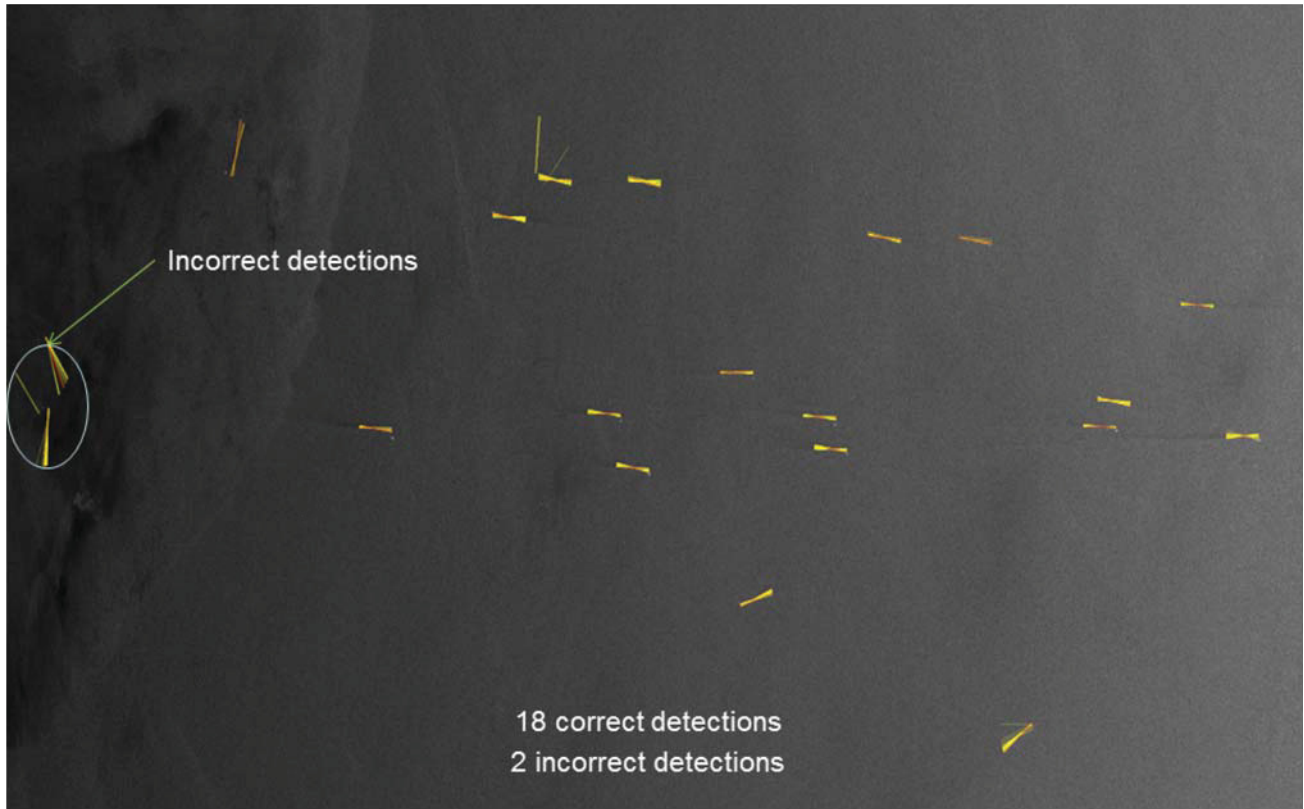


Figure 1: Ship wake detection result for a RADARSAT-2 EL1 image over Gibraltar

3 EXPLANATIONS OF INCOMPLETE TASK ITEMS

There are eight items that were not completed in Task 17. 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
1.1	Test SICD driver and upgrade as required	A draft SICD driver has been implemented for point target analysis, incidence angle and azimuth shift calculation. More testing is needed.
1.2	Port the DRDC-developed OceanSuite ship detection algorithm into IA Pro	This is viewed as a low priority item, and will be implemented in Task 20.
1.6	Upgrade the geospatial database interface to improve database searches by implementing a graphical SQL query builder (similar to IVVT thresholds) that is pre-populated with the available sensors and default thresholds	This is viewed as a low priority item, and will be investigated in the future.
1.7	Conduct requirements capture for geospatial database upgrade (e.g., more fields in the AIS table, same message for multiple sources, etc.), discuss options with SA, and implement	This is viewed as a low priority item, and will be investigated in future.
1.8	Stitch contiguous image frames to facilitate display	The ability to flip contiguous image frames to the desired polarization with a single button was implemented. More capabilities, such as two-dimensional radiometric balancing across multiple image frames, will be implemented in Task 20.

Item Number	Item	Status
2.1	Implement a module to pre-sort global AIS data to AOI and time in advance of association pipeline run	This is viewed as a low priority item, and will be investigated in future.
2.2	Extract ship information from an authoritative ship database (e.g., internet ships register on CANMARNET or a database to be provided by MSOC) based on MMSI and populate output message with ship identification, ship characteristics, and information provenance	This is viewed as a low priority item, and will be investigated in future.
2.3	Test compatibility with new AIS and SAR data sources and upgrade drivers as required	<p>The GDAL driver for OTHGold was upgraded to ingest OTHGold messages from Ship Detection Algorithms.</p> <p>Additionally, the ADSS driver for the Columbus AIS (ColAIS from Norway) was modified and upgraded to ingest type 1, type 5 and type 19 data and produce an Esri Shapefile (via CDL) for the detections, so that they can be displayed in IA Pro.</p> <p>Further work on the association between SAR and new AIS sensors such as AISSat-1 will be carried out in future.</p>