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Herc SAR Task 106: AIMS Feature Development

Final Report

Oliver Schoenborn and Paul Krga
CAE Professional Services

CAE Professional Services
1135 Innovation Drive, Suite 300
Ottawa, Ontario K2K 3G7

Project Manager: Paul Krga, 613-247-0342

Contract Number: W7711-047904/TOR/001

Contract Scientific Authority: Jacquelyn M. Crebolder, 902-426-3100 x296

Defence R&D Canada – Atlantic

Contract Report
DRDC Atlantic CR 2006-278
March 2007

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Author

Oliver Schoenborn

Approved by

Original signed by Jacquelyn Crebolder

Jacquelyn Crebolder

Approved for release by

Original signed by J. L. Kennedy

Kirk Foster

DRP Chair

Abstract

This document is the final report for Herc-SAR Task 106 – AIMS Feature Development. Several features to the AIMS simulation system, *AIMSsim* (previously called ELVISS), have been added to support human factors experimentation. The report summarizes the work performed and makes recommendations for the next phase. Software was developed to add scenario generation capability to the existing AIMSsim experimental research platform at DRDC. Core tasks were completed in the expected amount of time and some unplanned capabilities, such as path planning for targets, were added to the system to support an experiment by DRDC Atlantic.

Résumé

Le présent document est le rapport final du projet de Herc-SAR Task 106 sur l'élaboration des fonctions AIMS. Plusieurs caractéristiques du système de simulation AIMS, *AIMSsim* (anciennement appelé ELVISS), ont été ajoutées pour appuyer la recherche sur les facteurs humains. Le rapport résume les travaux effectués et fait des recommandations pour la prochaine phase. Un logiciel a été mis au point pour ajouter une capacité de génération de scénarios à la plateforme expérimentale AIMSsim existante de RDDC. Les tâches principales ont été complétées à l'intérieur de la période de temps prévue et quelques capacités imprévues, comme la planification de trajets pour les cibles, ont été ajoutées au système pour appuyer une expérience menée par RDDC Atlantique.

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Executive summary

Introduction

A multi-sensor surveillance system, the Advanced Integrated Multi-sensor Surveillance (**AIMS**) system, is being developed to increase the capability of Search and Rescue (**SAR**) and Maritime patrol. The AIMS system will enhance the capability of SAR particularly at night and in poor weather. Earlier versions of AIMS were the Airborne Laser Based Enhanced Detection and Observation System (**ALBEDOS**), and the Enhanced Low-Light Level Visible and InfraRed Surveillance System (**ELVISS**). The AIMS system advanced through the integration of four sensors into a single gimball. To ensure optimal performance the AIMS system requires an appropriate interface and controls, the design of which must realize the interaction between technological capability and operator performance. A research platform that simulates use of the airborne sensor interface and controls has been developed at Defence Research and Development Canada (DRDC) to support evaluation of interface design concepts and to address human performance issues related to operating the AIMS and similar electro-optical imaging systems.

Results

Several important features to the AIMS simulation system, *AIMSsim* (previously called ELVISS), have been added to support human factors experimentation and this document is the final report for Herc-SAR Task 106 – AIMS Feature Development. The report summarizes the work performed in the project and makes recommendations for the next phase. Deliverables for this task were the updated (interim) software executable, updated user and system manuals, updated (final) software executable and source code, as well as this final report. A full month of testing and fixing of the new functionality was completed by DRDC Atlantic. Subsequent to this, some new capabilities were added to the system, to support the pilot-testing experiment by DRDC Atlantic, and experiment scripts were created.

Future Plans

Recommendations for the next phase focus on improving the configurability of the display component, improving the Scenario Generation Environment (SGE) to synchronize it with the *AIMSsim* and expand its capabilities to support the extensive experimentation capabilities of *AIMSsim*, and improving the creation and maintainability of experiment scripts.

Significance

The experimental research platform at DRDC provides a means for ensuring that the user is an integral part of the design process and optimal design from the user's perspective is obtained. As technology advances and systems, like the AIMS, become more complex for an operator to use, user-machine system design becomes more critical and challenging. The continued development and upgrade of the *AIMSsim* research platform provides the experimenter with an appropriate level of simulation detail to conduct human peformance analyses which in turn delivers up-to-date knowledge and advice on the design of sensor surveillance systems to the military stakeholder.

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Sommaire

Introduction

Système multicapteur de surveillance, le **AIMS** est en cours de développement pour améliorer les capacités de recherche et sauvetage (**SAR**) et de la patrouille maritime. Le système AIMS optimisera les capacités de SAR plus particulièrement la nuit et dans de mauvaises conditions météorologiques. D'autres versions du système AIMS avaient déjà été développées, soit le système laser aéroporté perfectionné de détection et d'observation (**ALBEDOS**) et le système perfectionné de surveillance à intensification de lumière visible et à infrarouge (**ELVISS**). Le système AIMS est supérieur à ses prédécesseurs grâce à l'intégration de quatre capteurs dans un seul cardan. Pour offrir un rendement optimal, le système AIMS exige une interface et des commandes appropriées, dont la capacité doit intégrer les capacités technologiques et le rendement de l'opérateur. Une plateforme de recherche qui simule l'utilisation et la commande de l'interface de capteur aéroporté a été élaborée par Recherche et Développement pour la défense Canada (RDDC) afin d'appuyer l'évaluation des principes de conception et pour aborder les questions relatives au rendement humain lié à l'utilisation du système AIMS et de systèmes d'imagerie électro-optique semblables.

Résulats

Plusieurs importantes caractéristiques du système de simulation AIMS, *AIMSsim* (anciennement appelé ELVISS), ont été ajoutées pour appuyer la recherche sur les facteurs humains et le présent document est le rapport final pour le projet Herc SAR Task 106 : Développement des fonctions AIMS. Le rapport résume les travaux effectués et fait des recommandations pour la prochaine phase. Les résultats attendus pour cette tâche étaient le logiciel mis à jour exécutable (provisoire), la mise à jour du manuel de l'utilisateur et du manuel du système, la mise à jour du logiciel exécutable (définitif) et le code source, ainsi que la rédaction du présent rapport final. RDDC Atlantique a consacré un mois aux essais et aux ajustements des nouvelles fonctions du système. Ensuite, de nouvelles capacités ont été ajoutées au système pour appuyer des essais pilotes par RDDC Atlantique, et des scripts d'expérimentation ont été crées.

Portée

La plateforme de recherche expérimentale à RDDC a fourni des moyens pour s'assurer que l'utilisateur fait partie du processus de conception et que la perspective de ce dernier sur la conception optimale est connue. Tout comme la technologie, les systèmes comme AIMS se perfectionnent et deviennent de plus en plus complexes à utiliser pour un opérateur; la conception du système utilisateur-machine devient de plus en plus important et impose de nouveaux défis. Le développement continu et la mise à niveau de la plateforme de recherche *AIMSsim* procurent à l'expérimentateur assez de détail sur la simulation pour effectuer des analyses sur le rendement humain qui, à leurs tours, fournissent aux intervenants militaires une connaissance actuelle et des recommandations sur la conception de systèmes de capteurs de surveillance.

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Table of Contents

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1 Introduction

The objective of this Call-Up was to add several important features to the AIMS simulation system, *AIMSsim* (previously called ELVISS), to support Human Factors (**HF**) experiments at DRDC Atlantic.

The main deliverables from this tasking are the updated software executable, source code, and associated system and user manuals for the *AIMSsim* software, and this report, which summarizes the work done in this project.

1.1 Background

A multi-sensor surveillance system, the Advanced Integrated Multi-sensor Surveillance (**AIMS**) system, is being developed to increase the capability of Search and Rescue (**SAR**) and Maritime patrol. The AIMS system will enhance the capability of SAR particularly at night and in poor weather. Earlier versions of AIMS were the Airborne Laser Based Enhanced Detection and Observation System (**ALBEDOS**), and the Enhanced Low-Light Level Visible and InfraRed Surveillance System (**ELVISS**). The AIMS system is advanced through the integration of two sensors into a single gimball and the capability of rapid mounting on a non-dedicated aircraft. As such, the system will support timely SAR response using available aircraft equipped with the most advanced search and surveillance technology. Potential platforms for AIMS include a proposed fixed-wing SAR (**FWSAR**) aircraft and the CP-140 aircraft. To ensure optimal performance the AIMS system requires an appropriate interface and controls, the design of which must realize the interaction between technological capability and operator performance.

1.2 Objective

The objective of this Call-Up was to add several important features to the AIMS simulation system, *AIMSsim* (previously called ELVISS), to support HF experiments at DRDC Atlantic.

1.3 This Document

This document is the final report for *Herc-SAR Task 106: AIMS Feature Development*. Section 2 summarizes the deliverables accompanying this report. Section 3 of this document summarizes the work performed on this tasking. Section 4 makes some recommendations for the next phase of work.

2 Deliverables

All the deliverables have been burnt to a Compact Disk (**CD**), to be sent to DRDC Atlantic. The CD contains:

- Application:
  - AIMSsim-2_2_1.tar.gz: binaries and experiments
  - AIMSdb-2_2_1.zip: visuals database
- Source:
  - AIMS-2_2_1-SVN-Bak-Jul_06.zip: the Subversion database containing the code including a history of the code. The subversion application, freely downloadable from subversion.tigris.org, is required to access the source code inside this zip file. A Graphical User Interface (**GUI**) front-end for subversion, called TortoiseSVN (tortoiseSVN.tigris.org), makes this trivial.
- Documentation:
  - AIMSsim_Manual_System_Jul-2006.doc
  - AIMSsim_Manual_System_Jul-2006.pdf
  - AIMSsim_Manual_User_Jul-2006.doc
  - AIMSsim_Manual_User_Jul-2006.pdf
- Final report:
  - Herc-SAR Task 106 Final Report.pdf

3 Summary of Work Performed

This section summarizes the work performed under this tasking. The high level tasks from the Statement Of Work (**SOW**) are as follows:

1. Project management,
2. Add new features to *AIMSsim*,
3. Support DRDC Atlantic in developing an experiment using the new capabilities

Program management tasks, including the initial meeting were performed as planned. The activities from the two main technical tasks (2. and 3. above) are summarized in the following sections. The project work started in December of 2005 and ended in July of 2006.

In this phase, DRDC Atlantic decided that the software should be renamed from ELVISS to *AIMSsim*, to bring it up to date with the Standing Offer related to the AIMS system.

3.1 Add new features to *AIMSsim*

All features described in the original SOW were implemented, with the exception of #10, *Change Search History Display*. Other features, not anticipated in the original SOW, took precedence over this one.

Feature development led to departures from the original design, such as:

- It became apparent while adding target motion (feature #4) to the system, that having all terrain intersections computed by the display component would adversely affect the quality of the simulation. A solution was designed which decoupled the simulation component from the display component, while maintaining some coherence of algorithms in both components. This required extra time.
- It was determined that target motion could greatly benefit from the path following functionality available to the aircraft. A solution was designed that vastly expands the path-planning and following capabilities of aircraft and targets alike, allowing for complex, dynamic scenarios. This required extra time.
- The terrain database, taken from the previous version of the system, was found to be inadequate for DRDC Atlantic's planned experiment, due to presence of a tree-top surface spanning the whole terrain. The only practical solution was to temporarily make the clamping of targets onto the ground use the highest available terrain at the coordinate of interest. This required patching the software, until the terrain database can be redesigned and re-implemented in a future phase of the project.
- Updating the manuals required more effort than expected, due in part to various unplanned functions that had to be created or, in some cases, renamed to make the global naming more coherent and object-oriented, and also due to many capabilities and important concepts lacking any mention in the previous version of the manuals.
- The experiment changed often over the course of the project: the path, the events, the measurements. The actual measurements to make were defined only at the very end of the project and luckily the system was able to support them with only minor modifications to the source code. This required, in some cases, undoing some of the previous work.

Several of the planned tasks were completed in less time than expected, such that the core tasks (#1 to 11) completed by the end of February 2006. This left a month for DRDC Atlantic to thoroughly test the system prototype at their site. The software prototype was delivered at the end of March 2006, as per the SOW.

The remaining project time was used on the remaining tasks, on improving the target motion to use the path following capabilities until then available only to the aircraft, to ease the creation of DRDC Atlantic's experiment, and finally on helping DRDC Atlantic complete the creation of the experiment scripts in time for the pilot test to take place at the end of May, 2006 (this was not in the SOW), occupying about one person-month of work (see the next section).

The pilot testing revealed only minor fixes were necessary, plus the serious terrain tree-top surface problem mentioned above. The client decided that patching the terrain clamping of targets was the best option, albeit temporary.

In the end, the client had to extend the project by only 20 hours, and the schedule had to be extended from ending in May to ending in July.

3.2 Support for experiment development

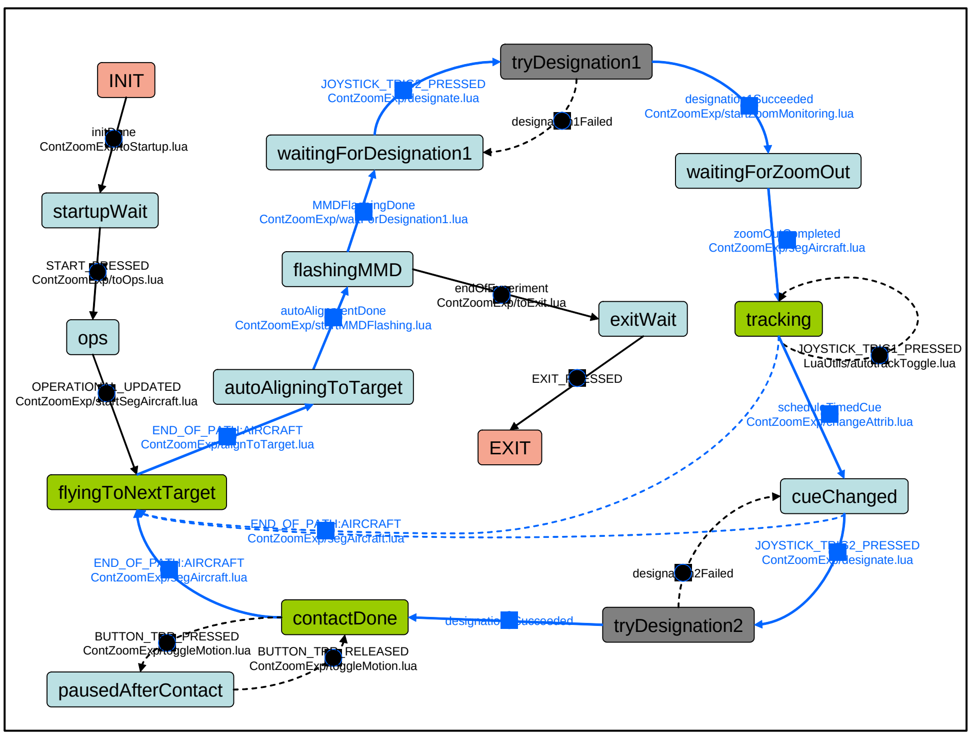
At the time of writing of the SOW, the experiment was only very vaguely defined, just enough to know what features to add to *AIMSsim*. As soon as the experiment was more defined, it became apparent that some of the features discussed in the previous section would have to be extended.

The final experiment is much more complex than was anticipated by either side, but is a very nice example of the power and robustness of this application. This extra complexity required more time for support in the development of the experiment scripts, not only due to the complexity per se, but because the extra complexity meant that DRDC Atlantic could not create as much of the experiment scripts as anticipated.

Some of the characteristics of the experiment:

- There are six types of experiments: aircraft loops around stationary target, target loops around stationary aircraft, and both loop around each other - each conducted under manual tracking conditions and under automated tracking conditions.
- The aircraft moves along a scanning-type path, going by targets along the way. The operator cannot control the camera orientation during this time.
- There are a large number of targets, positioned randomly on each side of the aircraft's path, according to the desired loop size.
- All participants in the experiment get the exact same aircraft path and target locations, yet the loop sizes and orientations are random within an experiment.
- Targets are activated (become visible) only when the aircraft arrives near their predefined target location.
- When arrived, the camera automatically aligns itself to where the target is expected to be, whenever the aircraft arrives at the target.
- The Moving Map Display (**MMD**) flashes for two seconds to notify the operator that they now have control of the camera orientation.
- The operator is forced to designate the visible target, then zoom out completely, before the experiment can proceed.
- The auto-tracking will be automatically turned on as soon as the loop is started, for three out of the six types of experiments.

- The aircraft will then loop around the stationary target, or the target loop around the stationary aircraft, or both loop around either other.
- After a time unknown to the operator, the target will change color, indicating to the operator that they must designate again.
- Tracking measurements take place while looping: the angular distance between the target and the center of the sensor window is saved to a data file, along with other various events. The field of view is also saved.
- If the operator does not designate a second time, before the loop has ended, the system properly moves on to the next stage of the experiment.
- The loops can have random deviations around a circular shape. Some loops will be right-handed, some left. The operator can never tell what the size or direction the next loop will be in, but all operators have the same loops.
- In test mode, the aircraft motion can also be paused and resumed, while tracking is not taking place.
- Thanks to the breakdown and representation of the experiment as a Finite State Machine in the software and scripts, the experiment always has control over operator input and other events:



4 Recommendations for the next phase

The following sections give some recommendations for the next phase, with explanations. Some of these recommendations incorporate information from discussions with DRDC Atlantic during the project.

4.1 Source Code Status

The current source tree was examined to determine the status of the existing source code.

The level of consistency between the Scenario Generation Environment (**SGE**) and *AIMSsim* is too low. E.g. the SGE does not make use of any of the code structures and functions used by *AIMSsim* for path-planning, target visibility flag, etc. This makes the transfer of data from SGE to *AIMSsim* rather prone to errors as both systems make different assumptions. The SGE should be synchronized with *AIMSsim* to make proper use of as many of the code structures as possible.

4.2 *SimControl*

The path following was not designed, originally, for tacking a path plan onto the end of another path plan. Though the design did turn out to support this capability, the fillets between two path plans do not behave properly when the last path segment is small. This situation should be corrected.

The logging functionality available to the scripts makes use of the very versatile logging library used in *AIMSsim*. Currently however there is no ability to create new log sinks and destroy log sinks, limiting the variety of files that can be created during an experiment. This capability should be added to the system to complete the logging feature.

Currently, the experiment initialization script must specify the terrain as one massive geometry file. This limits the re-usability of scene components. E.g. in the most recent experiment, the tree cover was not desired, but couldn't be removed from the terrain. If *AIMSsim* supported adding a terrain and attaching other objects to it, the tree cover could have been designed separately from the terrain and not included in the experiment. This would also allow for an experiment to choose which "obstacles" (buildings, bridges), or other geographical features (lakes, etc.) to include.

The scripting engine could use some improvements to make the experiments easier to create and maintain. E.g. all exported functions should be in a table so they are easy to identify as exported functions. Also, classes and methods should be used instead of functions, for targets, aircraft, and path plans at least.

4.3 *SimDisplay*

Scripting capabilities should be added to the display side of the system, to allow dialog screens to be created at run-time, for tasks like asking the user some questions, showing messages, etc. This would also allow the display to be configured, e.g. to toggle/position/size the different displays available.

The *simDisplay* uses dead reckoning to move targets on the terrain, when no new data is available from *simControl* for the new frame being displayed. The algorithm used for dead reckoning could be improved to lead to smoother motion.

The messaging system between *simControl* and *simDisplay* should be improved to prevent messages from arriving out of sync with their associated data from shared memory. This has not been a problem so far but the likelihood of a discrepancy increases with time. The sooner this is fixed, the less impact it will have on existing experiments.

The overlay text is really difficult to see. Real LCD displays have a background color that occludes the background image under the text, or the text lies outside of the image (though some overlays have to be over the image, e.g. in Automatic Target Recognition). It would be useful to add a background to text, or make it opaque or bigger or different color etc., or at least allow such attributes to be changed in the display configuration script.

4.4 Documentation

The application users could benefit from having the user and system manuals available online via HTML. This format would allow for a better separation of concepts yet make the documentation more easily navigable. The user and system manuals should be re-created in a web-friendly format, and material related to the SGE should be moved to a separate web-friendly document.

4.5 Scenario Generation Environment

It is recommended that the SGE interface should be cleaned up: several tabs refer to parameters which are no-longer available (they have been replaced by several parameters, set via function calls in scripts).

The SGE interface should support:

- Path-planning: ability to create any number of path plan objects (usable by aircraft and targets), instead of just one flight plan (usable by aircraft only), and to create a path plan from several other path plans.
- Simulation of path following: show a dot moving along a path plan to see how the waypoint fillet, speed and acceleration rate affect the trajectory and time taken to execute the path plan.
- Diagrammatic creation of the Finite State Machine (**FSM**) of an experiment: this would allow the experiment to create a series of labeled boxes and annotated lines, as in the FSM representation of the previous section, and generate the associated skeleton Lua code (script for FSM, and empty script for each transition). An annotation could be selected to start a Lua editor (third party application) on the associated script.
- Connection to *simControl*: a “simulation” mode could trigger the simulation in “test” mode, allowing for testing of the scenario created with the FSM editor and external Lua editor. This would start the display in a smaller window size, and display the events and scripts being run.

4.6 *SimInputs*

The hardware input should be made more generic: ability to support USB joysticks, and ability to configure the function of each input signal understood by *simControl*.

5 Summary of Report and Next Steps

This report details the deliverables for the project, mainly documentation, application and source, as well as the work performed to create those deliverables, including some of the hurdles that had to be surmounted, and finally makes a dozen or so recommendations for the next phase of *AIMSsim*.

The next step is for DRDC Atlantic to determine which, if any, of the recommendations should be implemented, and discuss with Greenley & Associates any other features or capabilities needed.

6 References

1. Schoenborn, O. (2001). *AIMSsim System Manual*. DRDC Toronto CR 2001-029; Greenley & Associates, Ottawa, Ontario.

2. Schoenborn, O. (2006). *AIMSsim User Manual*. DRDC Toronto CR 2001-030; Greenley & Associates, Ottawa, Ontario.

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3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

Herc SAR Task 106: AIMS Feature Development (U)
Herc SAR Task 106 : Développement des fonctions AIMS – Rapport final

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

Oliver Schoenborn

5. DATE OF PUBLICATION (Month and year of publication of document.) March 2007	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 16	6b. NO. OF REFS (Total cited in document.) 2

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical document, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

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8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring: National Search and Rescue Secretariat, 400−275 Slater Street, Ottawa, Ontarion, K1A 0K2
Tasking: DRDC Atlantic
DRDC Toronto

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.) 3373AO	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.) W7711−047904/TOR/001
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document) DRDC Atlantic CR 2006−278	10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)

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(U) simulator, human−machine interface, sensor, surveillance, search and rescue, maritime patrol, human performance

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