SISWS: Shipboard Integration of Sensors & Weapons System

There is a growing emphasis to extract the maximum performance from existing shipboard sensors and weapons, as the threat evolves, technology advances and the cost to replace them become prohibitive. Additional cost effective performance is available through updating the processing hardware; implementing advanced processing and sensor integration algorithms; and through better coordination of assets. Making these improvements, while retaining the existing sensors and weapons can result in a significant increase in ship survivability, without incurring the costs associated with replacing the systems. The use of models and simulators will quantify the predicted increase in performance to ensure that the changes are worth doing.

With respect to Above Water Warfare (AWW), there is a clear and critical need to address the advances in threat systems and the consequent demands on shipboard operations, particularly with regard to littoral environments. Trends in anti-ship missiles include supersonic speeds, traveling at lower altitudes, and smaller radar cross sections. These systems may use a combination of active and passive homing, thus making them more difficult to detect by a ship's sensors and providing less reaction time for the ships' weapon systems. Emerging threats with imaging seekers in the optical and millimetre wave bands will render traditional countermeasures ineffective. As modern sensor and weapon technologies evolve in order to counter increasingly sophisticated threats, the volume, rate and complexity of information will steadily grow.

There is a clear need for the integration of shipboard sensors and weapons to support higher level shipboard command and control functions and to enable critical new approaches to ship self defence against anti-ship missiles.

The purpose of the Defence R&D Canada SISWS Technology Demonstration Project is to develop, validate and demonstrate new technologies aimed at improving the survivability of a ship through the use of novel AWW sensor and weapon management techniques. SISWS will demonstrate that an integrated AWW sensor and weapons management system can:

- extend ship's engagement limits;
- win back reaction time; and
- increase the probability of successful engagements.

These technologies will be investigated, modelled, developed, evaluated, and demonstrated, partially thorough a sea trial. This approach will be followed for the main SISWS activities:

- demonstrating real time *environmental modeling* system to the ships to assist Command in employment of sensors and weapons; and interfacing environmental modeling tools to the sensor and weapon managers to optimize the use of these resources;
- validating the *sensor management* processes that yield improvements in track information thus increasing chance of survivability; and
- validating the *weapon management* techniques that will optimize ship's survivability and maximize number of engagements.

Environmental Modeling

Shipborne environmental models can be fed with real metrological data gathered from the ship's sensors. These models will calculate the effects of terrain, clutter and propagation characteristics of the environment, to predict the performance of own ship's search and track sensors. The ranges at which the ship is detectable to hostile sensors can also be calculated with a knowledge of the infrared (IR) and radar transmission characteristics, coupled with our own ship's signature models. This shipboard capability can provide real time operational decision support to the ship's commander.

Ship's signature models have been generated to assess the vulnerability of the ship to weapons that guide on the IR image or use the radar cross section (RCS) of the ship to reflect electro-magnetic energy. The ship's RCS data is generated by performing electro-magnetic scattering calculations using a computer-aided design model of the ship; these predictions are validated using a radar for taking measurements of the ship. Figure 1 shows the flash (brighter colours) of an increase in the RCS section of the Canadian Forces Auxiliary Vessel (CFAV) Quest. Models have also been made of several other vessels, such as the Canadian Patrol Frigates and conceptual models of the Joint Support Ship (JSS).

Once validated, the model can be used to predict the effectiveness of signature reduction measures such as design changes and the addition of radar absorbing materials.

Sensor Manager

The SISWS sensor manager will have four specific roles:

- cue the surveillance sensors with Alert/Caution sectors;
- send Situation Awareness (SA) data to the Electronic Support (ES) sensor;
- provide the interface between the surveillance sensors and the Command and Control System (CCS); and
- provide selected surveillance sensor data to the weapon manager.

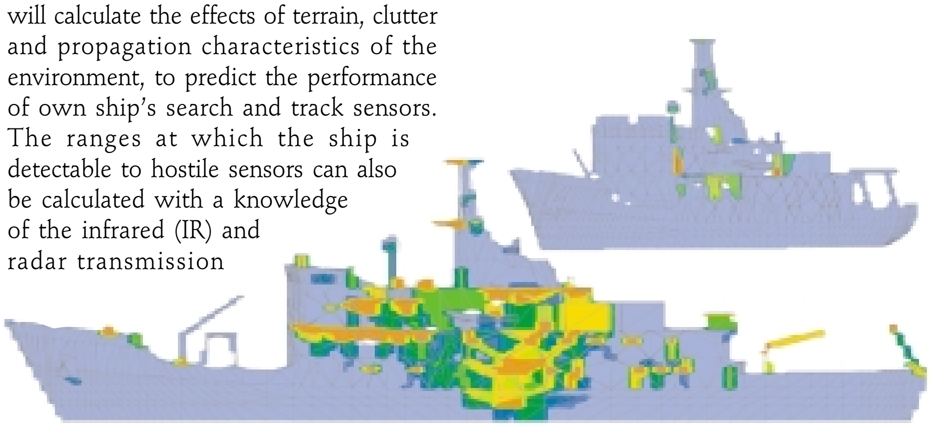
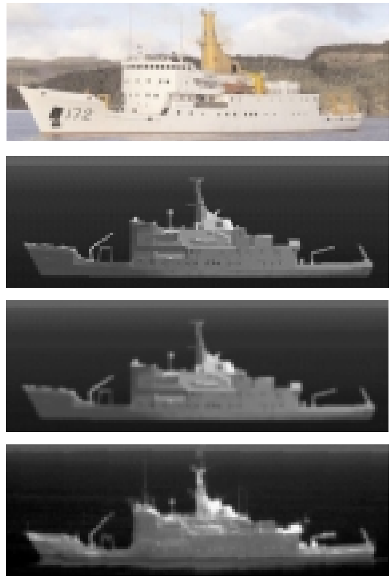


Figure 1: Ship Signature models show the "flash" of CFAV Quest's increase in radar cross section at broadside and off broadside angles. Dark colors indicate a small RCS; brighter colors indicate a "hotspot" or large RCS, due to a corner reflector, or vertical surface reflecting energy back to the radar system. These increase the visibility of the ship to threats.

Shipboard search and track sensors can benefit from information integration with other dissimilar sensors. Information from one sensor can be used to cue another and increase the sensitively in a given area in order to detect the target earlier. Additional information from a radar on the target's altitude and speed can be used to get a better identification from the electronic support measures.

The Virtual Maritime System Architecture (VMSA) was selected as the framework for the SISWS simulation testbed (see figure 2). It is a software framework, which allows simulation models of various maritime systems to be brought together to create a virtual representation of a maritime combatant. These models may be complex entities such as warships, missiles, aircrafts or sub-systems of these complex entities such as sensors (infrared search and track (IRST), electronic support measures (ESM), radar), weapons (hardkill and softkill), navigation, counter-measures systems, and command and control systems. This simulation testbed will be used by scientists for future algorithm development, Canadian Forces Maritime Warfare Centre for tactics development and by the Operational staff for team training/debriefing.



Images of CFAV Quest

The first image is a photo.

The second image is produced by the ShipIR model showing its predicted infrared (IR) signature in the 3-5μm band.

The third image adds in blurring to model atmospheric and camera effects. ShipIR predicts infrared ship and background signatures (radiance, intensity, contrast, temperature).

The fourth image is an actual measured infrared image of Canadian Forces Auxially Vessel (CFAV) Quest.

There is very good correlation of the ship's "hot spots" between the predicted and the real. This model can be used with atmospheric inputs to predict the ship's visibility to enemy sensors and to predict the effectiveness of countermeasures such as IR flares. Similarly, models of the signatures of missiles and other targets will also be used to assess the ship's ability to detect them under various conditions and provide this as a real time input to the ship's commander.

Weapon Manager (WM)

One of the SISWS WM's primary roles is to monitor data from the sensors associated with weapons (fire control radar, jammer receiver, and possibly the Close In Weapon System receiver) and automatically update the weapons with new data from the surveillance sensors or other sources as appropriate. The WM provides automated and dynamic control of the weapons and maintains position estimation for off-board decoys/reflectors. Performance prediction, using data from all sensors and Intelligence, will feed into a decision support tool, proposed for the Warfare Combat Officer (WCO) to permit optimization of his tasks. The WM will perform softkill/hardkill coordination, and aid in kill assessment using data from sensors. It will also interface with the Sensor Manager.

Softkill effectiveness can be predicted using models. For instance, ENGAGE models an engagement between a sea skimming, anti-ship missile and a ship target equipped with an active onboard jammer. Ship's sensors can determine the operating mode of the missile's guidance and provide feedback on the effectiveness of the shipboard Electronic Countermeasures Measures (ECM). This will provide the commander with confidence that the missile can be affected early in the scenario and increase the effectiveness of the jamming by indicating when to stop jamming or try a different technique. The simulation will predict the operating mode of the missile (i.e.: Home on Jam) and provide guidelines for when and how to best jam a missile.

Many of the concepts and algorithms developed, will be considered for incorporation in the new Halifax-Class Modernized Command and Control System (HMCCS) and the Radar Upgrade Project (RUP). Completed sensor studies have verified improved target detection in radar and IRST sensors through the use of cues and improved quality of track reports in ESM through the use of dissimilar data obtained from other sensors. Completed weapon studies show improved probability of ship survival using coordinated on-board/off-board softkill assets and improved probability of ship survivability using dynamic close-loop electronic attack concepts.

Shipboard trials on the CFAV Quest will take place in the fall of 2005. The SISWS project will complete in March 2007. FL

Close Loop Simulation Representation

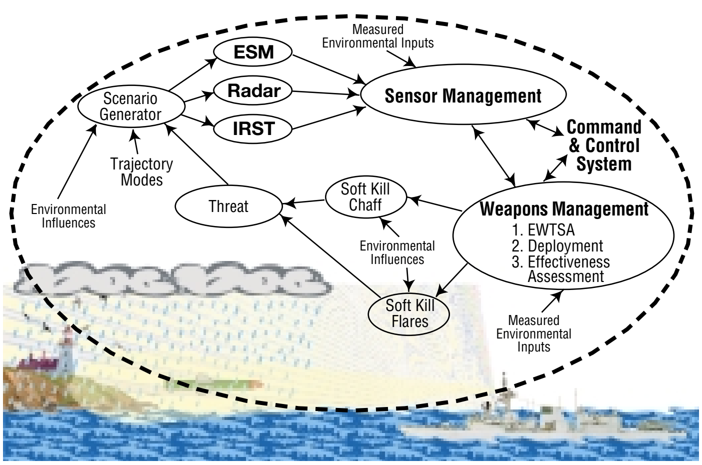


Figure 2: SISWS Simulation Testbed showing the closed loop nature of a maritime missile engagement scenario based on the Virtual Maritime System Architecture.

Greg Walker is with Directorate of Science & Technology Maritime at Defence R&D Canada.

Dr. Ingar Moen is the Director S&T Policy at Defence R&D Canada.