Copy No. _____

Defence Research and Development Canada
Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

# Maritime Force Protection Technology Demonstration Project Underwater Threats Component Build 1 Trial Plan


*Anna Crawford*
*D. Vance Crowe*
*David Hopkin*



**Defence R&D Canada – Atlantic**

Technical Memorandum
DRDC Atlantic TM 2008-189
November 2008


Canada

This page intentionally left blank.

# Maritime Force Protection Technology Demonstration Project Underwater Threats Component Build 1 Trial Plan

Anna Crawford
D. Vance Crowe
David Hopkin

**Defence R&D Canada – Atlantic**

Technical Memorandum
DRDC Atlantic TM 2008-189
November 2008

Principal Author

*Original signed by Anna Crawford*

Anna Crawford

Defence Scientist

Approved by

*Original signed by David Hopkin*

David Hopkin

Head, Maritime Asset Protection Section

Approved for release by

*Original signed by Ron Kuwahara for*

Document Review Panel, DRDC Atlantic

Work undertaken as part of the Maritime Force Protection Technology Demonstration Project, Underwater Threats Component.

# Abstract

(U) As part of the Maritime Force Protection Technology Demonstration Project (MFP TDP), DRDC Atlantic is investigating technologies for detection and identification of divers or swimmers posing a threat to an asset. A trial is planned as part of that program which includes a month-long deployment of a diver detection sonar (DDS) at CFB Shearwater. The trial has several goals: 1) to gain familiarity with the DDS and other new equipment, such as underwater loud hailers and environmental measurement instruments, 2) to test reacquisition of contacts first tracked by the DDS by a small response craft equipped with high-frequency identification sonar, and 3) to assess DDS performance using an acoustic propagation model with measured local environmental inputs. Divers from Fleet Diving Unit (Atlantic) will participate in the trial, both in deployment/recovery of equipment and in swimming in the sonar field of view to act as targets for the DDS. A small Autonomous Underwater Vehicle (AUV), a Slocum Glider, will also participate as both a sonar target and for measurement of environmental parameters. This trial follows on from a series of demonstrations of commercial-off-the-shelf DDS systems held in December 2006 and March 2007 at the same site.

# Résumé

(U) Dans le cadre du Projet de démonstration de technologies de protection de la Force maritime, RDDC Atlantique examine des technologies de détection et d'identification de plongeurs ou de nageurs constituant une menace contre une ressource militaire. On a ainsi planifié des essais qui comprennent l'utilisation pendant un mois d'un sonar de détection des plongeurs à la base des Forces canadienne de Shearwater. Ces essais ont comme objectifs (1) de se familiariser avec ce sonar et d'autres instruments comme les mégaphones sous-marins et les instruments de mesure du milieu; (2) de tester la ré-acquisition de cibles d'abord suivies par le sonar de détection, par un sonar d'identification à haute fréquence, monté sur une petite embarcation d'intervention; et (3) d'évaluer le rendement du sonar à l'aide d'un modèle de propagation acoustique utilisant les données du milieu local. Des plongeurs de l'Unité de plongée de la Flotte (Atlantique) contribueront à l'essai en installant et récupérant le matériel et, nageant dans le champ observé, en lui servant de cible. Un véhicule sous-marin autonome, un planeur Slocum, sera également de la partie. Il jouera le rôle de cible sonar et mesurera des paramètres du milieu. Ces essais suivent une série de démonstrations des systèmes sonar de détection de plongeurs sur les mêmes lieux, organisée en décembre 2006 et mars 2007.

This page intentionally left blank.

# Executive summary

## Maritime Force Protection Technology Demonstration Project Underwater Threats Component Build 1 Trial Plan

**Anna Crawford; D. Vance Crowe; David Hopkin; DRDC Atlantic TM 2008-189; Defence R&D Canada – Atlantic; November 2008.**

**Introduction:** As part of the Maritime Force Protection Technology Demonstration Project (MFP TDP), a trial is planned to conduct experimentation in detection and identification of underwater intruders using sonar. The trial focuses on a month-long deployment at CFB Shearwater of a commercial-off-the-shelf (COTS) diver detection sonar (DDS). During the trial, divers from Fleet Diving Unit (Atlantic) will assist with equipment deployment/recovery and will participate on several days by swimming in the sonar field of view. DDS performance in detecting and tracking divers will be evaluated, assisted by modeling of the local acoustic environment based on measurements of local water properties (e.g. temperature and sound velocity). Other concepts or technologies that will be tested include tasking of a small response boat to reacquire/classify targets tracked by the DDS and warning off of divers using an underwater loud hailer system. This trial follows on from a series of demonstrations of commercial-off-the-shelf DDS systems held last year at the same site.

**Results:** An invaluable data set will be obtained during this trial that will include DDS tracking results collected from real divers, comprehensive accompanying environmental data, and information allowing performance assessments of the DDS and response boat, and more.

**Significance:** The program of work being undertaken in the Underwater Component of the MFP-TDP is intended to address current deficiencies to counter underwater threats to CF ships in harbour and anchorages. The threats being considered are swimmers (aided and non-aided); divers (open and closed circuit breathing gear); and, Autonomous Underwater Vehicles (AUVs). This trial provides in-field experience with several technologies identified as being key components to an integrated underwater threat response: the DDS, loud hailers, environmental monitoring devices, etc.

**Future plans:** This trial completes the first in a series of three Builds planned as a spiral development strategy for execution of the TDP. Experience gained during this trial will feed directly into the continuing development in the future Builds.

# Sommaire

## Maritime Force Protection Technology Demonstration Project Underwater Threats Component Build 1 Trial Plan

**Anna Crawford; D. Vance Crowe; David Hopkin; DRDC Atlantic TM 2008-189; R & D pour la défense Canada – Atlantique; Novembre 2008.**

**Introduction:** Dans le cadre du Projet de démonstration de technologies de protection de la Force maritime, nous planifions des expériences de détection et d'identification d'intrus par sonar. D'une durée d'un mois, ces essais porteront sur un sonar de détection de plongeurs, commercial sur étagère (COTS). Pendant les essais, des plongeurs de l'Unité de plongée de la Flotte (Atlantique) installeront et récupéreront le matériel et, plusieurs jours de suite, nageront dans le champ observé par le sonar. On évaluera le rendement du sonar pour la détection et le suivi des plongeurs, grâce à la modélisation du milieu acoustique, à partir des mesures des propriétés locales de l'eau (p. ex. la température et la vitesse du son). On testera des idées ou des technologies, notamment l'envoi d'une petite embarcation d'intervention qui confirmera ou classifiera les cibles suivies par le sonar et les avertira à l'aide d'un mégaphone sous-marin. Ces essais suivent une série de démonstration de systèmes sonar de détection de plongeurs, commerciaux sur étagère, tenus l'an dernier, sur les mêmes lieux.

**Résultats:** Nous prévoyons que ces essais engendreront un ensemble précieux de données composé de résultats du suivi sonar de plongeurs réels, des données auxiliaires complètes sur le milieu, des informations permettant d'évaluer le rendement des sonars, de l'embarcation d'intervention et d'autres.

**Importance:** Le programme de travail entrepris par la composante sous-marine du Projet de démonstration de technologies de protection de la Force maritime veut corriger des lacunes actuelles de la protection contre les menaces sous-marines visant les navires des Forces canadiennes au port ou à l'ancre. Les menaces considérées sont les nageurs (assistés ou non), les plongeurs (avec appareil respiratoire à circuit ouvert ou fermé) et les véhicules sous-marins autonomes. Ces essais permettront d'acquérir une expérience pratique de plusieurs technologies qui seraient des composantes clés d'une intervention en cas de menace sous-marine : le sonar de détection de plongeurs, le mégaphone sous-marin, les dispositifs de mesures du milieu, etc.

**Perspectives:** Cet essai sera le premier d'une série de trois étapes d'une stratégie évolute de développement visant la réalisation du projet de démonstration de technologies. L'expérience acquise pendant les essais sera directement exploitée lors des étapes suivantes.

# Table of contents

# List of figures

# List of tables

# 1 Overview

The Maritime Force Protection Technology Demonstration Project (MFP-TDP, 11gq) is a 4-year program in its second year. It has been divided into 4 Components: 1) Command-and-Control (C2) and Integration, 2) Vulnerability and Recoverability, 3) Surface Threats and 4) Underwater Threats. The Underwater (UW) Component focuses on addressing deficiencies in the current CF capabilities for countering underwater threats to Canadian ships in harbours and anchorages. The threats being considered include divers (aided, unaided, open and closed-circuit breathing apparatus), swimmers and Autonomous Underwater Vehicles (AUVs). The UW Component program is a series of three Builds incorporating incremental improvements in capability using a spiral development approach, increasingly integrating capabilities from the four project components. Each Build culminates in a trial, the present being the first Build trial.


*Figure 1: Aerial view of CFB Shearwater, NA jetty and Eastern Passage.*

An aerial photo of the area around NA jetty at CFB Shearwater is shown in Figure 1. Trial activities will be centred around the jetty. This was the site of a series of commercial Diver Detection Sonar (DDS) demonstrations hosted by the MFP-TDP in December 2006 and March 2007. This trial is a progression from those demonstrations and many aspects of operations will be similar. One of the four DDS systems that was demonstrated has subsequently been procured (QinetiQ Cerberus) and lessons learned during the demonstrations can be applied to this trial.

One of the overall concepts that will be the basis for trial activities is illustrated in Figure 2 (not to scale). A series of concentric boundaries will be established around the jetty that define an experimental security zone (shown by the yellow lines in Figure 2). The DDS will be deployed off the jetty at a location that provides coverage over this zone. The distances to the boundaries will be determined based on studies that have been conducted by the MFP-TDP Surface Threats component. A three-part scenario begins with detection and tracking by the DDS of an underwater threat that is seen to proceed into the security zone. In the second stage, the response boat is tasked to investigate the contact, approaching from a heading that does not obscure the threat from the DDS or its own high-frequency identification sonar with wake bubbles. Once a position and identification for the contact have been determined by the response boat, this information is relayed to the shore station and the third stage is a broadcasted warning to the contact using the loud hailer.

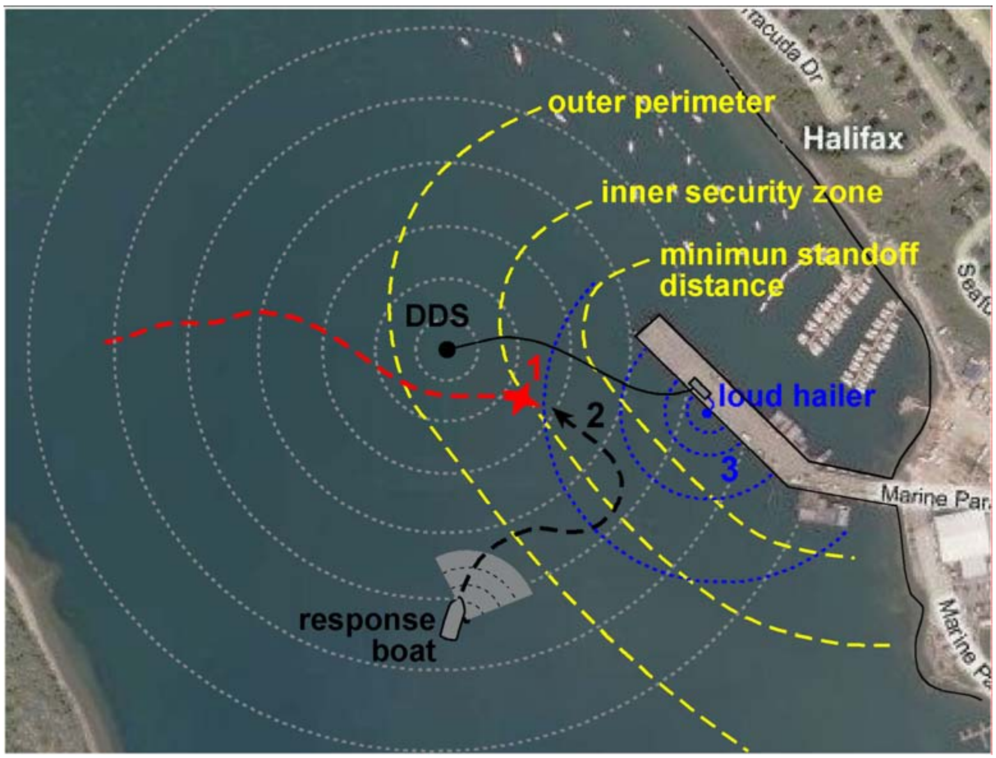


*Figure 2: Overview of one of the concepts being exercised during the Build 1 trial.*

A second concept that will be investigated during the trial is through-the-sensor sonar performance assessment. Through the trial, environmental measurements will be made in the waters surrounding the DDS to characterize the acoustic environment in the area. These measurements will act as inputs to an acoustic propagation model that will assist in determining sonar detection performance dependant upon time, range and bearing from the DDS. Model results will be verified by measuring acoustic transmission loss.

# 2 Trial Objectives

The MFP-TDP Project Implementation Plan (PIP) specifies the following objectives for the UW component:

1. Conduct trials and experiments with underwater sensors to assess the current state-of-the-art (SOA) in countering a variety of underwater threats to Canadian ships in harbours and anchorages, including aided and non-aided swimmers and divers with improvised explosive devices and closed-circuit breathing gear, and AUVs;

2. Using guidance from Marlant OR, TTCP studies, and CFMWC on Force Protection Concepts of Operation (COP), identify potential gaps between the current SOA and potential future CF FP requirements;

3. Based on maximum risk and impact, explore technical solutions to address potential capability gaps;

4. Support a spiral development test & trials program, integrated with CD&E, that incrementally integrates capabilities from each of the four project components; and

5. Provide a recommended way-ahead to the CF on Force Protection against the identified underwater threats.

The Build 1 trial addresses the first, third and fourth objectives directly and the experience coming from a field deployment of systems in a Force Protection role will provide input for progress on the others.

The objectives of the Build 1 trial can be summarized in three areas:

1. Demonstrate DDS operational usage – During the trial, the DDS will be operated in a realistic environment against real divers. This will provide invaluable experience and a data set for follow-on research. The QinetiQ Cerberus DDS has been newly acquired and there will be some effort required in training operators that can follow the system through subsequent usage through the MFP-TDP and beyond. Diver runs will be planned during this trial that test aspects of DDS performance, such as in areas of high clutter or, if environmental conditions are conducive, in areas where propagation conditions limit capability.

2. Through-the-sensor performance assessment – Environmental measurements will be made (water temperature, sound speed and velocity) that will serve as inputs to an acoustic propagation model. The model results will be verified by making acoustic measurements. In addition, fixed and movable targets will be placed in the sonar field of view. The Slocum Glider serves as both a mobile environmental monitoring device and a target. A long-term goal is to eventually be able to provide operators with a real-time updating measure of the DDS performance, perhaps in a geographically referenced format, i.e. highlighting regions of the sonar coverage area where detection performance is expected to be poor. As a start during this trial, a post-processing approach will be taken as there will be no real-time access to the environmental data.

3. Contact reacquisition and identification – In a complete detect-to-engage sequence, there is a follow-on response to an initial threat detection. This was not exercised during the demonstrations, however during this trial, a small response boat carrying an identification sonar will be tasked to investigate targets that are detected and tracked by the DDS. Observers from the MFP-TDP C2 Component may assist with observation and assessment of the response effectiveness. Two high-frequency sonars will be trialed for diver identification purposes on the response boat: the Imagenex 837 and the BlueView P450.

Other trial activities will support minor objectives, such as testing and evaluation of equipment that has been recently procured for the MFP-TDP continuing program, such as the loud hailer and environmental monitoring equipment.

# 3 Trial Activities

During the month-long deployment of the DDS, various trial activities will be scheduled based on personnel and equipment availability and weather conditions, interspersed with periods where the DDS will be unattended. Summaries of the various trial activities are given below.

## 3.1 Equipment Deployment and Recovery

The 20’ container shelter will be moved from the DRDC yard to the NA jetty at the start of the trial period. It will require a power hook-up and if possible telephone. It will be demobilized from the jetty early in the week following the trial.

Deployment and recovery of the DDS will be performed with the assistance of FDU divers and a crane. The sonar head and attached seabed mount is lifted by crane off the jetty and into the water, a lift bag is attached by divers, it is towed by the divers’ RHIB to its deployment location and then let down to the seabed by deflating the lift bag. Floats will be attached to the sonar cable to prevent it dragging on the seabed interfering with deployment. These will be removed once the sonar is in place. Recovery follows the reverse of this sequence. Further information on the DDS deployment, recovery and installation procedures, can be found in the manufacturer supplied documentation, which will be provided to all parties concerned [see reference 1]. The sonar deployment/recovery procedure was performed successfully and safely multiple times during last year’s DDS demonstrations. The length of the shore cable to the sonar head is 250 m, so the deployment location for the sonar will be within that distance of the container on the jetty.

Other equipment and instrumentation (thermistor chain, Acoustic Doppler Current Profiler, fixed targets) will be deployed and recovered in a similar manner, using the crane only if required to safely lift the weight.

## 3.2 Diver Runs

A series of diver runs will be planned that exercise the capability of both the DDS and the response craft. The diver runs on a given day will depend on weather conditions and diver availability and will be planned in detail at the time with the dive supervisor. These will be described to all concerned parties in a daily morning briefing. In general, each dive will consist of swimming at a near constant heading and near constant depth for between 15 – 30 minutes, for a total distance of between 100 and 500 meters. The maximum depth will not exceed 20 m. In addition, several of the dives will require the use of an underwater scooter. This scooter is a COTS tool that is often used by divers to provide a higher transit speed. Also, some of the dives will be completed using closed circuit breathing apparatus. For each dive, the FDU(A) dive master will ensure that all diving operations follow safety protocols.

The divers will typically be at distances of 100 to 1000 m from the sonar. While the sonar is safe to touch while operating, an exclusion zone of 25 m will be established. This will mitigate any possible entanglement or inadvertent bumping of the sonar. The loudhailer will also be deployed within a 25 m exclusion zone, ensuring safe operation for the divers.

## 3.3 Diver Reacquisition

The intention is to task a small response boat carrying an identification sonar (small, high-frequency imaging sonar) to investigate targets that have been detected and tracked by the DDS. The response boat will be directed to approach a target location from a particular heading, so as not to contaminate the fields of view of both the DDS and the ID sonar with wake bubbles. Once in position, the ID sonar will be deployed from the response boat and the operator will search for the presence of something that has been tracked by the DDS. Results of the search (something found or not, possible identification, location and heading of contact) will be relayed to the shore station.

Tasking of the response boat will be accomplished through use of a ruggedized laptop networked to a shore station (WiMAX) located in the container on the jetty. The laptop will be equipped with chart-based tactical display software that interfaces with a GPS on the response boat. The response boat will be supplied with instructions including a contact location to investigate and an approach vector.

## 3.4 Diver Warning

When a successful detection and reacquisition sequence has been completed, diver runs will be terminated by loud hailer warning to the diver. As with the DDS, a 25 m exclusion zone will be established around the loud hailer position to ensure diver safety.

## 3.5 Sonar Performance Assessment

Environmental measurements will be made to characterize the local acoustic propagation conditions. These will be used as inputs to an acoustic propagation model (Bellhop) for prediction of sonar detection performance in the sonar coverage area. A dedicated PC for running the model will be installed in the shore container. The model results will be verified by making transmission loss measurements at points in the sonar coverage area. The transmission loss measurements will be made from a small boat using a calibrated hydrophone (Reson).

The environmental measurements will consist of sound velocity and water volume current measurements. Sound velocity profiles will be measured using an Applied Microsystems Ltd. Sound Velocity Profiler (SVP) from a small boat and from the jetty and by measuring profiles of water temperature with a fixed vertical thermistor chain mooring (equipment details and deployment to be determined). Temperature profiles will also be provided in almost-real-time by the Slocum Glider (see following section). Water volume velocity measurements will be made using an Acoustic Doppler Current Profiler. The velocity measurements will not be available until the instrument has been recovered and the data downloaded post-trial. An Environment Canada weather station is conveniently located on the jetty, though online access to this data has a week lag.

## 3.6 Glider Runs

The Slocum Glider platform will provide a valuable almost-real-time environmental monitoring capability, at the same time as being a small stealthy sonar target, while it transits back and forth across the sonar coverage area. This capability was tested during the commercial DDS demonstrations, though the acoustic modeling that used the glider water temperature profiles was done post-trial at that time. The glider also has the capability of measuring ambient sound levels in a frequency band between 2 and 40 kHz.

During the commercial DDS demonstrations, glider runs transited back and forth along the axis of Eastern Passage, in the centre of the channel. Several shorter passes were also run oriented perpendicularly, across the entrance to Eastern Passage. These are effective routes for the glider, given the spatial constraints of the Passage.

## 3.7 DDS Jamming

The DDS system can be effectively jammed by transmitting confusing acoustic pulses from a nearby location at frequencies in the DDS receive band. This will be tested during the trial by transmitting pulses from the jetty or from the response boat.

## 3.8 DDS Familiarization

Since this will be the first significant deployment of this new DDS equipment, some time will be spent during the trial in training operators. This will benefit future deployments.

# 4 Trial Schedule

The trial will take place during the 5-week period from September 15 to October 17, 2008. During the first part of the week September 15-16, a 20' container shelter will be placed on the NA jetty and connected with services, and this will be removed early in the week following the trial, October 20 or 21. Deployment of the DDS and other *in situ* instrumentation will occur on Wednesday September 17, with the assistance of divers from Fleet Diving Unit (Atlantic) Underwater Engineering, weather permitting. Testing of the shore-connected equipment, in particular the DDS, will be performed on Thursday September 18 and 19. During the following 3 weeks, various trial activities will be scheduled including response boat workups and operations, DDS testing with targets, loud hailer testing and series of environmental measurements. During this period, operators will become familiar with the new DDS and other equipment. It is intended that there will be periods when the DDS will run unattended, including but not limited to weekends. Scheduling of specific trial activities during this period is pending. Beginning on Monday October 6, there will be two or three days of operations with the Slocum Glider. Divers are not expected to be involved in trial activities while the glider is operating. Following the Thanksgiving holiday Monday, there will be three days of operations with FDU(A) CCDA (rebreather) divers, October 14 to 16. The DDS and other deployed instruments will be recovered, with diver assistance, on Friday October 17.

*Table 1: Calendar of trial events, Sept-Oct 2008.*

| Mon | Tues | Wed | Thurs | Fri |
|---|---|---|---|---|
| 15 Sep<br>container to jetty, hook up | 16 | 17 deploy DDS & other UW equipment | 18 DDS & other UW equipment testing | 19 DDS & other UW equipment testing |
| 22<br>DDS familiarization, small boat ops (targets, env. measurements), response boat ops, SCUBA diver ops when FDU(A) pers. available | 23 | 24 | 25 | 26 |
| 29 | 30 | 1 | 2 | 3 |
| 6 Glider ops | 7 Glider ops | 8 Glider ops | 9 | 10 |

| | | | | |
|---|---|---|---|---|
| 13 Thanks-giving Holiday | 14 CCDA diver ops | 15 CCDA diver ops | 16 CCDA diver ops | 17 recover sonar & other UW equipment |
| 20 demobilize container | 21 | 22 | 23 | 24 |

# 5 Trial Resources

## 5.1 Equipment

A sorted list of required equipment is included as Annex A. Following are descriptions of most of the larger items.

### 5.1.1 20’ Container Shelter

*Figure 3: Container on the jetty, March 2007.*

The container will be placed on the jetty to serve as a shore station for the DDS and as a general operations centre for the trial. This same container was used during the commercial sonar demonstrations in 2007. It is wired for a 440 V connection with internal power distribution for 110 V circuits and some 220 V. It has windows, two heavy doors and 4” glands. Some furniture (tables, chairs) will be required. For the demonstrations in 2007, the container was placed on the seaward side of the jetty, close to a power service terminal, about half way along the length of the jetty from the shore end.

### 5.1.2 QinetiQ Cerberus DDS

*Figure 4: The wet end of the QinetiQ DDS.*

The QinetiQ Cerberus DDS wet end will be deployed off the jetty as described previously, cabled to the shelter container where the dry end processor and associated equipment will be situated. It is a commercial off-the-shelf sonar that operates with a bandwidth of 20 kHz within a frequency range of 80 – 120 kHz, with a nominal maximum power output of 208 dB (re. 1 μPa @ 1m). The wet end of the sonar is 0.7 m in diameter and 1.4 m high, and weighs 250 kg in air. It sits on a seabed mount with adjustable tilt. The dry end consists of a processor computer and power supply housed in a half-height 19” rack mount. The sonar cable will pass through a gland in the container wall and mate with a custom break-out box. The sonar power supply requires 220-240 V, 50-60 Hz.

### 5.1.3 Loud Hailers

The loud hailer system that will be tested is a Broadband Acoustic Transmission System (BATS). It transmits intelligible messages at audible frequencies from 300 Hz to 5 kHz, with maximum power output of 182 dB (re 1 μPa @ 1m). It uses a Multi-Mode Pipe Projector acoustic underwater transmitter developed at DRDC.

### 5.1.4 Response Boat Equipment

The response boat platform is a modified CF RHIB called a Barracuda, which has been outfitted as an unmanned surface vehicle (USV), but will not be operated as such during this trial. The RHIB will be fitted with a high-frequency imaging sonar on an over-the-side pole mount, a GPS, a WiMAX radio network link and a tactical display laptop. Two imaging sonars will be tested during the trial: an Imagenex 837 and a BlueView P450E. The Imagenex 837 is a small hand deployable device weighing 2.25 kg in air that operates at 260 kHz. The nominal power output is not specified by the manufacturer, but typically devices of this kind output 210 dB (ref. to 1 μPa @ 1m). The BlueView P450 is of similar size (2.6 kg) and acoustic output power, operating at 450 kHz. Electrical power for the extra equipment being added to the RHIB for this trial is supplied by a pair of standard car batteries (12/24 V DC). A minimum of two people will be required for operation of the response boat: a sonar operator (DRDC) and boat driver (CF).

### 5.1.5 Environmental Measurement Equipment

Environmental measurements will be made using several independent methods. Water column velocity profiles will be logged by an RDI Acoustic Doppler Current Profiler (ADCP) deployed by divers near the jetty in Eastern Passage. This is an internally logging device so data will not be available until the instrument is recovered. Sound velocity profiles will be collected from a small boat and from the jetty using an Applied Microsystems Ltd SVPLus. These profiles can be available in almost-real-time to use as input for acoustic propagation modelling. Water temperature profiles will be measured using a moored thermistor chain device (to be determined). Most likely this data will not be available until downloaded from the instrument after recovery. The results of acoustic propagation modelling will be verified by measuring acoustic transmission loss using Reson calibrated hydrophones, logged using an IOtech Personal DAQ 3000 acquisition system on a ruggedized laptop. The acoustic propagation model (Bellhop) that uses the environmental inputs will be run on a dedicated PC located in the shore container on the jetty.

### 5.1.6 Spoof Ping Generating Equipment

Acoustic pings that are transmitted nearby in the DDS operating frequency band can effectively jam the DDS. For this purpose, International Transducer Corp. transducers, a signal generator and an Instrument Inc Power Amplifier will be used.

### 5.1.7 Slocum Glider

The Slocum Glider is an autonomous buoyancy-driven device that compiles vertical profiles of water properties while following a vertical sawtooth path between programmed waypoints. It navigates by dead reckoning between GPS fixes acquired while surfaced at the waypoints and has some rudimentary adaptive course correction ability to correct for currents. The model owned by DRDC is equipped with a Seabird CTD probe and a hydrophone. While surfaced, data collected on the past leg can be telemetered allowing for near real-time environmental monitoring. The glider is easily deployed and recovered manually from small craft. During the trial, the glider will be programmed to fly paths along the axis of the channel just off the jetty. In addition to acquiring environmental data, the glider itself serves as a stealthy almost diver-sized acoustic target.

*Figure 5: Slocum Glider being released.*

### 5.1.8 Divers' Equipment

Diver position will be recorded using a marker float equipped with a small GPS receiver. The diver on track will tow the marker float. At the discretion of the dive supervisor, some runs may be performed during the last week of the trial with unmarked CCDA divers. Some diver runs will also be performed assisted by a diver delivery vehicle X-Scooter. Other than these items, divers will use FDU(A) equipment.

*Figure 6: X-Scooter diver delivery vehicle*

### 5.1.9 Acoustic Targets

Acoustic targets will be towed from a small boat and deployed at fixed locations in the DDS field of view for assessment of sonar performance. Targets that have been used for this same purpose in the past are a metal corner reflector, a weighted SCUBA tank and weighted spheres of various size and composition.

### 5.1.10 Miscellaneous

The following will be used during the trial, mostly on the jetty: range-finder binoculars, ICOMS-6 VHF marine radios, digital camera, floater coats and life jackets, power bars, coffee maker, general stationery supplies.

# 6 Subsidiary Plans

## 6.1 Safety

The following activities have been identified as having an element of risk, however the appropriate procedures should ensure safe operations.

Dive Operations

Dive operations will be the top focus of safety during this trial. All dive operations and safety issues will be the responsibility of FDU(A). A liaison with FDU(A) has been established. FDU(A) will designate a dive coordinator for each day who will liaise with DRDC Atlantic on site. A least one briefing of each day's dive operations will be carried out by the dive coordinator in cooperation with the Chief Scientist or his delegate.

Small Boat Use

Under the direction of the Chief Scientist, small boat operations will be conducted by qualified DRDC Atlantic and CF personnel in the response boat and in a second small boat to collect environmental data and to place targets in the sonar field of view. Appropriate safety procedures will be followed in all instances.

Equipment Installation and Removal

Installation of the sonar wet-end equipment will be carried out under the direction of the DRDC Atlantic Chief Scientist or his delegate. Transportation and installation of the shore station container will be arranged through QHM and Base Operations. Safe lifts and electrical connections will be performed by qualified individuals according to current regulations and procedures.

## 6.2 Human Factors Assessment

It is the policy of DRDC that no research involving human participants can be conducted by DRDC employees without the prior approval of the DRDC Human Research Ethics Committee (HREC), which is responsible for reviewing proposals to ensure that the research is conducted safely in accordance with prevailing standards, relevant legislation, and related policies. This review has taken place and a revised Protocol Numbered L-650 was filed with the HREC and approved on 13 August 2008.

The divers will typically be at distances of 100 to 1000 m from the DDS. While the sonar is safe to touch while operating, an exclusion zone of 25 m will be established for the trial. This will mitigate any possible entanglement or inadvertent bumping of the sonar. A similar zone will be established around the loud hailer. The identification sonar on the response boat poses no risk to divers due to its extremely high frequency and short pulse lengths.

Under direction from this Protocol L-650, each diver who takes part in this trial will be briefed on the DDS and the swims that he or she will be making. The purpose of the trial is to exercise the DDS and its usage and it is explicitly not a test of the individual. Each diver may make inquiries from the HREC and the DRDC investigators before and after the tests and each participant will acknowledge their understanding of the tests by signing a voluntary consent form for human subject participation.

## 6.3 Environmental Assessment

The planned demonstration will have a relatively minor environmental impact on this area. Nonetheless, an environment assessment has been carried out and filed with the DRDC Atlantic Environmental Officer. This plan is filed as EA 1267-1431-08/09-04. That EA plan details the procedures for mitigating any impact on both the marine environment and local human activities.

The EA plans are summarized here. The area around NA Jetty is a marine neighbourhood with a heavy human presence. Any physical damage is to be kept to a minimum. The impact of the active sonars is minimal, with no long-term effects expected. The DDS uses very short and very high frequency pulses: 0.005-second long pulse at 90-110 kHz repeated at intervals of about one second. Divers can safely touch the sonar head. However to ensure safe operations, a mitigation zone of 25 m will be established and any marine mammal or human intrusion within this zone will result in operations stopping during the intrusion. The identification sonars operate at extremely high frequency and pose no risk to marine mammals. The loud hailers operate at audible acoustic frequencies and will also be assigned a 25 m mitigation zone.

## 6.4 Information Security Plan

It is not expected that classified data will be created during this trial. DRDC Atlantic consulted with FDU(A) and members of the MFP-TDP working group prior to the commercial DDS demonstrations last year to confirm this. The unclassified designation is in keeping with past trials at the US Navy NAVSEA, NATO Harbour Protection Trials 2006, NURC Harbour Protection Trials and NURC Response Against Diver Intrusions Joint Research Project. Within the NATO navy and reseach communities, target strength data on commercial scuba divers is unclassified.

Data will be created that may be sensitive from an operational perspective. The sensitive data indicating probability of detection and false alarm will also be unclassified from an *information technology* viewpoint but will be handled on computers that are not connected to the internet.

FDU(A) were consulted prior to the commercial DDS demonstrations in 2007 as to the information security designation of the rebreather equipment used. They responded that active sonar data of this type is unclassified. FDU(A) were informed that if they wish to change the designation of the DDS data from unclassified, then this change can be handled properly. Should there be a change, personnel will be briefed on the sensitivity of that data and it will be handled appropriately.

## 6.5 Data Collection Protocol and Processing Plan

Data will be collected as outlined elsewhere in the trials plan. The personnel made responsible for each of the various trials activities will check the data collected during those activities for quality during the trial. Second level data quality assessment will be done by the scientist-in-charge.

Detailed analysis of the some of the environmental data will not be possible until data has been downloaded from the instruments post-deployment (ADCP velocity profiles, perhaps temperature profiles from the thermistor chain) or until some processing has been done to create useful products (transmission loss measurements, sound velocity calculated from water temperature). The environmental data collected by the glider and the sound velocity profiler, on the other hand, will be available almost-real-time and these can be used as inputs to the acoustic propagation model.

The DDS produces raw sonar data at a very high rate – 32 GB/day for beamformed data, 40 GB/hour for the stave data. Measures will be taken that ensure this data is safely stored, however creating daily backups of this volume of data is probably not feasible. The sonar software also allows logging of tracks and contacts, which are in data files of a much more manageable size. These, along with the almost-real-time environmental data, can be backed up to DVD on a daily basis. The data rates for the identification sonars are also manageable and daily back ups of this data will be done from the ruggedized laptop where that data will be logged.

# References

[1] General Deployment Procedures for Cerberus Off-Shore Unit (OSU), Carl Stone and Ian Wolff, QinetiQ Ltd, Farnborough, UK, 42 pgs.

# Annex A Equipment List

QinetiQ Cerberus DDS – wet end, dry end, cable, keyboard, monitor, power supply

BATS loud hailer – Xmit array, power/controller unit

20’ Container - at NA Jetty to house personnel, sonar work station, computers, etc
- Folding chairs, cushions, desks, shelves, tables
- Power bars, desk lamps, heaters, coffee maker
- Misc. laptop(s) to process SVP and other environmental data
- Night scope, binoculars, optical/laser Rangefinder
- Digital camera
- Pan-tilt-zoom camera(?)
- Wind meter
- DOT approved life jackets, life ring, safety lines
- ICOMS-6 radios - VHF marine band capable with external antenna.
- Handheld GPSs, Garmin 76
- WiMAX shore station, antenna

Environmental Measurements
- Reson H/Ps, high gain amplifier and filter, IOtech DAQ and laptop, 12 V batteries
- RDI Broadband Acoustic Doppler Current Profiler (ADCP)
- AML Sound Velocity Profiler
- Weather station
- Seabird CTD probe(?)
- Thermistor chain(?)

Passive targets – sphere, corner reflector, SCUBA tank

Spoof ping generator – ITC transducers, signal generator, Instrument Inc Power Amplifier

X-Scooter – diver propulsion vehicle (DPV), rented.

Diver marker float equipped with GPS

Response Boat – Barracuda 7-m RHIB
- WiMAX network radio link mobile station and shore station, antennas
- Imaging sonars – Imagenex 837, BlueView P450, laptop
- DC power - car batteries, inverter
- Sonar over-the-side pan/tilt mounting pole
- Hands free sonar bi-ocular display
- Tactical display ruggedized laptop
- DGPS, antenna/receiver

Slocum Glider, control computer laptop, and associated comms equipment

Work boat (Zodiac), safety equipment

# List of symbols/abbreviations/acronyms/initialisms

| | |
|---|---|
| ADCP | Acoustic Doppler Current Profiler |
| AUV | Autonomous underwater vehicle |
| BATS | Broadband Acoustic Transmission System |
| C2 | Command and Control |
| CCDA | Closed-circuit diving apparatus (rebreather) |
| CD&E | Concept Development and Evaluation |
| CFB | Canadian Forces Base |
| CFMWC | Canadian Forces Maritime Warfare Centre |
| COTS | Commercial-off-the-shelf |
| CTD | Conductivity Temperature Depth |
| DDS | Diver detection sonar |
| DND | Department of National Defence |
| DRDC | Defence Research & Development Canada |
| FDU(A) | Fleet Diving Unit (Atlantic) |
| GPS | Global Positioning System |
| HREC | Human Research Ethics Committee |
| MDA | MacDonald Dettwiler and Associates |
| MFP-TDP | Maritime Force Protection Technology Demonstration Program |
| NURC | NATO Undersea Research Centre |
| OR | Operations Research |
| PIP | Project Implementation Plan |
| POC | Point of Contact |
| QHM | Queen’s Harbour Master |
| RHIB | Rigid hulled inflatable boat |
| SCUBA | Self-contained underwater breathing apparatus |
| SOA | State-of-the-art |
| SVP | Sound Velocity Profile/Profiler |
| TTCP | The Technical Cooperation Program |
| USV | Unmanned Surface Vehicle/Vessel |
| UW | Underwater |

# Distribution list

Document No.: DRDC Atlantic TM 2008-189

**LIST PART 1: Internal Distribution by Centre**

2 PM/MFP TDP (1 CD, 1 hardcopy)
5 Library (4 CDs, 1 hardcopy)
1 H/TD
1 H/WP
1 H/MAP

10 TOTAL LIST PART 1

**LIST PART 2: External Distribution by DRDKIM**

1 NDHQ/DRDKIM

1 Library and Archives Canada

1 Chris McLaughlin
MacDonald Dettwiler and Associates Ltd
60-1000 Windmill Rd
Dartmouth, NS B3B 1L7

1 Dana Maxwell
MacDonald Dettwiler and Associates Ltd
60-1000 Windmill Rd
Dartmouth, NS B3B 1L7

1 Cdr D. Peer
DGMEPM/DMSS 2
National Defence Headquarters
555 Blvd de la Carriere
Hull, PQ K1A 0K2

1 LCdr Dreimanis
DGMFD/DMRS 3-5
Chief of Maritime Staff
MGen George R. Pearkes Building
101 Colonel By Drive
Ottawa, ON K1A 0K2

1 LCdr Brisseau
DGMPR/DMPOR 4-4
Chief of Maritime Staff
MGen George R. Pearkes Building
101 Colonel By Drive
Ottawa, ON K1A 0K2

1 Cdr Keith Dawe
N49/ Base Operations Officer
Maritime Forces Atlantic
PO Box 99000 Stn Forces
Halifax, NS B3K 5X5

1 Maj. Greenaway
N493/ Naval Provost Marshall Atlantic
Maritime Forces Atlantic
PO Box 99000 Stn Forces
Halifax, NS B3K 5X5

1 LCdr S Tofflemire
N494/ Queen's Harbour Master
Maritime Forces Atlantic
PO Box 99000 Stn Forces
Halifax, NS B3K 5X5

1 Paul H Saunders
Deputy Chief of Staff Operational Research
Maritime Forces Atlantic N02OR
PO Box 99000 Stn. Forces
Halifax, NS B3K 5X5

1 SO Tactics SuW - FP, AWW Coord
Canadian Forces Maritime Warfare Centre
Halifax, NS B3K 5X5

1 Cdr TM Howard
Queen's Harbour Master
Port Operations and Emergency Services
Canadian Forces Base Esquimalt
PO Box 17000 Stn Forces
Victoria, BC V9A 7N2

1 LCdr J MacLean
Port Security Section
Port Operations and Emergency Service Branch
Canadian Forces Base Esquimalt
PO Box 17000 Stn Forces
Victoria, BC V9A 7N2

14 TOTAL LIST PART 2

**24 TOTAL COPIES REQUIRED**

## DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

| | |
|---|---|
| 1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.)<br><br>Defence R&D Canada – Atlantic<br>9 Grove Street<br>P.O. Box 1012<br>Dartmouth, Nova Scotia B2Y 3Z7 | 2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)<br><br>UNCLASSIFIED |

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)

Maritime Force Protection Technology Demonstration Project Underwater Threats Component Build 1 Trial Plan

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Crawford, A. M.; Crowe, D. V.; Hopkin, D. A.

| | | |
|---|---|---|
| 5. DATE OF PUBLICATION (Month and year of publication of document.)<br><br>November 2008 | 6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)<br><br>34 | 6b. NO. OF REFS (Total cited in document.)<br><br>1 |

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

Technical Memorandum

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

Defence R&D Canada – Atlantic
9 Grove Street
P.O. Box 1012
Dartmouth, Nova Scotia B2Y 3Z7

| | |
|---|---|
| 9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)<br><br>MFP TDP | 9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.) |
| 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.)<br><br>DRDC Atlantic TM 2008-189 | 10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.) |

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

Unlimited

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

(U) As part of the Maritime Force Protection Technology Demonstration Project (MFP TDP), DRDC Atlantic is investigating technologies for detection and identification of divers or swimmers posing a threat to an asset. A trial is planned as part of that program which includes a month-long deployment of a diver detection sonar (DDS) at CFB Shearwater. The trial has several goals: 1) to gain familiarity with the DDS and other new equipment, such as underwater loud hailers and environmental measurement instruments, 2) to test reacquisition of contacts first tracked by the DDS by a small response craft equipped with high-frequency identification sonar, and 3) to assess DDS performance using an acoustic propagation model with measured local environmental inputs. Divers from Fleet Diving Unit (Atlantic) will participate in the trial, both in deployment/recovery of equipment and in swimming in the sonar field of view to act as targets for the DDS. A small Autonomous Underwater Vehicle (AUV), a Slocum Glider, will also participate as both a sonar target and for measurement of environmental parameters. This trial follows on from a series of demonstrations of commercial-off-the-shelf DDS systems held in December 2006 and March 2007 at the same site.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Maritime Force Protection Technology Demonstration Project; diver detection

This page intentionally left blank.