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Trials Plan: Post HCM/FELEX First of Class Standardization and Manoeuvring/ Controllability Trials on HMCS CALGARY

Eric Thornhill

Defence R&D Canada – Atlantic

Technical Memorandum

DRDC Atlantic TM 2013-098

November 2013

Canada

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Abstract

This report presents a plan for standardization and manoeuvring/controllability trials for HMCS CALGARY which has recently completed its midlife modernization as part of the Halifax-class Modernization (HCM)/Frigate Life Extension (FELEX) program. Existing data for standardization and manoeuvring/controllability for the HALIFAX Class frigates is from a trial in 1991 on HMCS HALIFAX when the ships were newly built. This data is somewhat limited due to a number of technical problems encountered during the trial at that time. The ships now operate at a deeper displacement and have undergone a number of appendage changes. In addition to documenting the performance of the ships post HCM/FELEX refit, which is of primary concern to operators, the results of the trial will provide more complete and up-to-date information for ship simulators and research & operations modeling.

Résumé

Le présent rapport comprend un plan d'essais de normalisation, de manœuvre et de facilité de commande du NCSM CALGARY, qui a récemment subi des travaux de modernisation de mi-vie dans le cadre du programme FELEX. Les données existantes visant la normalisation, la manœuvre et la facilité de commande des frégates de la classe HALIFAX proviennent d'essais réalisés en 1991 sur le NCSM HALIFAX, peu de temps après la construction des navires de la classe Halifax. Ces données sont quelque peu limitées en raison d'un certain nombre de problèmes techniques rencontrés au cours de ces essais. Les navires concernés sont dorénavant exploités selon un plus grand déplacement et les appendices de leur coque ont subi un certain nombre de modifications. En plus de permettre la consignation du rendement de ces navires après le radoub dans le cadre du programme de modernisation des navires de la classe Halifax (MCH)/prolongation de la vie des frégates (FELEX), ce qui constitue une priorité aux yeux des exploitants, les résultats des essais fourniront de plus amples renseignements à jour relativement aux simulateurs de navigation et à la modélisation pour fins de recherche et d'exploitation.

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Executive summary

Trials Plan: Post HCM/FELEX First of Class Standardization and Manoeuvring/ Controllability Trials on HMCS CALGARY

Eric Thornhill; DRDC Atlantic TM 2013-098; Defence Research and Development Canada – Atlantic; November 2013.

Background: The Halifax Class ships are in the process of a midlife modernization. Upon completion of the refit, the Halifax Class will operate at a deeper displacement and will have a number of appendage changes. Historical data for the vessels goes back to 1991 when the original standardization and manoeuvring/controllability trials were done, but it is somewhat limited due to a number of problems encountered during the trials at that time. New standardization and manoeuvring/controllability trials are planned for HMCS CALGARY in the fall of 2013 off the coast of British Columbia.

Principal results: This report presents a plan for standardization and manoeuvring/controllability trials to be conducted on Canada's west coast on HMCS CALGARY in the fall of 2013. The plan covers the required instrumentation, the trials agenda, and procedures needed to execute the trial and collect the necessary data.

Significance of results: In addition to documenting the performance of the ships post HCM/FELEX refit, which is of primary concern to operators, the results of the trial will provide more complete and up-to-date information for ship simulators and research/ operations modeling.

Future work: Future work will involve the execution of the trials as per this plan and analysis of the resulting data set.

Sommaire

Trials Plan: Post HCM/FELEX First of Class Standardization and Manoeuvring/ Controllability Trials on HMCS CALGARY

Eric Thornhill ; DRDC Atlantic TM 2013-098 ; Recherche et développement pour la défense Canada – Atlantique ; novembre 2013.

Contexte : Les navires de la classe Halifax subissent actuellement des travaux de modernisation de mi-vie. Une fois le radoub terminé, ces navires seront exploités selon un plus grand déplacement et les appendices de leur coque subiront un certain nombre de modifications. Les données historiques relatives à ces navires datent de 1991, où l'on a effectué les essais initiaux de normalisation, de manœuvre et de facilité de commande. Ces données sont toutefois quelque peu limitées en raison d'un certain nombre de problèmes rencontrés au cours des essais. Des nouveaux essais de normalisation, de manœuvre et de facilité de commande sont prévus pour le NCSM CALGARY à l'automne 2013, au large de la côte de la Colombie-Britannique.

Résultats principaux : Le présent rapport comprend un plan d'essais de normalisation, de manœuvre et de facilité de commande auxquels doit être soumis le NCSM CALGARY sur la côte ouest du Canada, à l'automne 2013. Ce plan porte sur les instruments requis, le calendrier des essais, ainsi que les procédures nécessaires à la réalisation des essais et à la collecte des données requises.

Portée des résultats : En plus de permettre la consignation du rendement de ces navires après le radoub dans le cadre du programme de modernisation des navires de la classe Halifax (MCH)/prolongation de la vie des frégates (FELEX), ce qui constitue une priorité aux yeux des exploitants, les résultats des essais fourniront de plus amples renseignements à jour relativement aux simulateurs de navigation et à la modélisation pour fins de recherche et d'exploitation.

Recherches futures : Le travail futur consistera à réaliser les essais conformément au présent plan et l'analyse de l'ensemble de données obtenu.

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1 Introduction

The twelve HALIFAX Class Frigates launched during the period 1988 to 1995, form the backbone of the Royal Canadian Navy (RCN). The ships were designed in the late 1970s and early 1980s to accomplish the Cold War Anti-Submarine Warfare (ASW) and Anti-Surface Warfare (ASUW) missions primarily in the open ocean environment.

The operational profile of the HALIFAX Class has changed. Current and evolving threat systems are faster, stealthier, more manoeuvrable and are moving from open-ocean areas to the littoral environment.

The HALIFAX Class Frigates are undergoing a midlife refit managed under the HCM/ FELEX project. The modernization of the ships will include the implementation of new capabilities into the ships which are required to meet the new threats and changing operating environments, as well as maintenance and sustainment work needed to keep equipment at its current level of capability [2].

A number of the Engineering Changes (ECs) planned for the refits will affect the displacement of the vessels and see the addition or removal of some hull appendages. Such changes can have an impact on the speed, acceleration and manoeuvring / controllability of a ship.

Lightship displacement is expected to increase by 5% from 4086 T to 4294 T from the time of the last inclining to post-FELEX. This will result in a draft increase of 0.139 m at the deep departure displacement. In addition to a stern flap that is being added to the design in order to improve fuel economy, there are plans to remove the masking belt and related canoe fairings.

Standardization and Manoeuvrability/Controllability (M/C) trials [3] were performed in 1991 when the original ships were delivered to the RCN from Saint John Shipbuilding Limited (SJSL), but the resulting data is somewhat limited due to a number of technical problems encountered during the trial at that time.

The changes to the ship class due to refit and the incomplete data from previous trials necessitate the planned standardization and M/C trials. In addition to documenting the performance of the ships post HCM/FELEX refit, which is of primary concern to operators, the results from the currently planned trial will also provide more complete and up to date information for ship simulators and research/operations modelling.

This report discusses the details for sea trial for HMCS CALGARY to be performed off the coast of British Columbia in September 2013. The trial will consist of runs for both the Standardization Trial Agenda [4] and Manoeuvring/Controllability Trial Agenda [5]. This trial plan supersedes those agendas as modifications/additions have been made to the run lists and procedures.

The trial will be conducted by personnel from the Naval Platform Operational Limits (NPOL) Group of the Warship Performance (WP) Section from Defence Research and Development Canada (DRDC) Atlantic. This work was assigned to DRDC with a MARCORD Task Request initiated by Mr. B. Carroll (DNPS 2-3) and approved by Cdr. D.M. Sims (DNPS-2).

2 Trial Conditions

2.1 Operational Area

The trial manoeuvres will be conducted in the West Coast Firing Area (WCFA) in the La Perouse bank area off the coast of British Columbia approximately 100-150 nmi from Canadian Forces Base Esquimalt. This location meets the requirements of an unconfined area with steady (non-fluctuating) ocean currents free from shipping traffic with a water depth not less than 50 m. This location has the added advantages of being in the vicinity of an Ocean Data Acquisition System (ODAS) buoy and Differential GPS (DGPS) tower (see Table 1).

Table 1: Weather Buoys and DGPS Towers Near Proposed Operational Area

DGPS Towers		
Name	Latitude	Longitude
Alert Bay	50.58°N	126.92°W
Amphitrite Pt.	48.92°N	125.55°W
Richmond	49.18°N	123.12°W
Sandspit	53.23°N	131.82°W
ODAS Buoys		
Name	Latitude	Longitude
La Perouse Bank - 46206	48.83°N	126.00°W
South Brooks - 46132	49.73°N	127.92°W

2.2 Sea State

Standardization and Manoeuvring/Controllability trials should be conducted in mild environmental conditions. The trials agendas [4], [5] indicate that the sea state must be 2 or less as defined by Table 2, while International Towing Tank Conference (ITTC) recommended procedures [1] suggest maximum conditions of Sea State 3. Some guidelines for correcting trial results for environmental conditions are given in [6], but [7] notes that "*these correction methods are developed somewhat more intuitively than scientifically*" and explicitly indicates that for sea states of 5 or more that corrections are not reliable.

Wind and waves will be monitored throughout the trial. Wind will be recorded using the ship's port and starboard anemometers and visual observations of Sea State (SS) will be logged throughout the trial. A directional wave buoy (see Section 3.8) will be brought on-board but only deployed if conditions appear to exceed sea state 2.

Table 2: Sea State Table for the Open North Atlantic (NATO, 1993) [8]

Sea State Number	Significant Wave Height (m)		Sustained Wind Speed (knots)[1]		Percentage Probability of Sea State	Modal Wave Period (s)	
	Range	Mean	Range	Mean		Range[2]	Most Probable[3]
0-1	0 - 0.1	0.05	0 - 6	3	0.70	-	-
2	0.1 - 0.5	0.3	7 - 10	8.5	6.89	3.3 - 12.8	7.5
3	0.5 - 1.25	0.88	11 - 16	13.5	23.70	5.0 - 14.8	7.5
4	1.25 - 2.5	1.88	17 - 21	19	27.80	6.1 - 15.2	8.8
5	2.5 - 4	5	22 - 27	24.5	20.64	8.3 - 15.5	9.7
6	4 - 6	5	28 - 47	37.5	13.15	9.8 - 16.2	12.4
7	6 - 9	7.5	48 - 55	51.5	6.05	11.8 - 18.5	15.0
8	9 - 14	11.5	56 - 63	59.5	1.11	14.2 - 18.6	18.64
>8	>14	>14	>63	>63	0.05	18.0 - 23.7	20.0

[1] Ambient wind sustained at 19.5 m above surface to generate fully developed seas. To convert to another altitude, H_2, apply $V_2 = V_1(H_2/19.5)^{1/7}$.

[2] Minimum is 5th percentile and maximum is 95th percentile for periods given wave height range.

[3] Based on periods associated with central frequencies included in Hindcast Climatology.

2.3 Engine Configurations

The HALIFAX Class frigates are twin screw, single rudder ships powered by two Gas Turbine (GT) engines and one Propulsion Diesel Engine (PDE) in a Combined Diesel or Gas (CODOG) plant arrangement. Power can be delivered to one or both propeller shafts using the PDE, a single GT, or both GTs. Normal modes of operation are those in which the engine power is distributed to the shafts through a Cross Connected (X-CONN) gearbox which maintains equal shaft rotation rates to the port and starboard propellers [9].

The trials agenda [5] calls for certain runs to be performed using a single driving propeller shaft. There are two possibilities for the non-driving shaft; locked or trailing. A locked shaft requires significant effort (1.5 - 2 hours) to engage the locking mechanism and is limited to a maximum torque corresponding to approximately 20 knots. Trailing a shaft involves disengaging one of the cross-connection clutches, thereby unitizing the driving shaft. There are operational limits associated with this mode of operation. Runs will not be performed if they require exceeding these limits.

Ship speed can be affected by altering propeller shaft rotation rate and/or by altering propeller blade pitch. Unless otherwise indicated in the trial agenda, the pitch/shaft rate combination required for a given ship speed shall be in accordance with standard practice as used in the Integrated Platform Management System (IPMS). Trial logs shall indicate time varying shaft rate, pitch setting (may also be time varying at low speeds), and engine configuration used for each run.

3 Instrumentation and Data Collection

To maximize the benefits of these trials, considerable data must be collected concerning the ship and environmental conditions. Some data will be logged with native ship systems, while others will require specialized instrumentation. Table 3 summarizes the required data.

The data acquisition will be set up as a number of self-contained units throughout the ship (they will not be networked together). Data collection units will be located in: the near vicinity of the ship's Centre of Gravity (C.G.), the chart room, steering gear compartment, on-deck at the bow, the hanger, on-deck aft of the flight deck, and in the engine room (forward and aft).

With the exception of the fuel flow meters (Section 3.10), all trial related equipment will be installed by the DRDC trial team shortly before the trial start, and completely removed at the end of the trial. Installation will take approximately two days and removal will take several hours.

Table 3: Trial Measurements

Measurement	Units	Data Rate	Section Reference
Date and Time	UTC	1 Hz	3.1, 3.6
Ship Location	Lat,Long	1 Hz	3.1, 3.7, 3.11
Ship Relative Position	m	1 Hz	3.2
Ship Speed	knots	1 Hz	3.1, 3.7, 3.11
Ship Course	deg (true)	1 Hz	3.1, 3.7, 3.11
Ship Heading	deg (true)	1 Hz	3.1
Roll	deg	20 Hz	3.5
Pitch	deg	20 Hz	3.5
Vertical Acceleration	m/s^2	20 Hz	3.5
Lateral Acceleration	m/s^2	20 Hz	3.5
Longitudinal Acceleration	m/s^2	20 Hz	3.5
Rudder Angle	deg	20 Hz	3.12
Shaft Rate (P&S)	RPM	1 Hz	3.4
Shaft Torque (P&S)	kNm	1 Hz	3.4
Shaft Power (P&S)	kN	1 Hz	3.4
Propeller Pitch (P&S)	deg	1 Hz	3.4
Fuel Consumed (per Engine)	m^3/hr	0.2 Hz	3.10
Engine(s) Operating	-	Per Run	3.4, 3.13
Gearing Configuration	-	Per Run	3.4, 3.13
Active Auxiliary Systems	-	Per Run	3.4, 3.13
Air Temperature	°C	1 Hz	3.1, 3.9
Barometric Pressure	Pa	1 Hz	3.1, 3.9
Water Temperature	°C	1 Hz	3.1
Water Density	kg/m^3	Daily	3.3, 3.13
Water Depth	m	1 Hz	3.1
Relative Humidity	%	1 Hz	3.1, 3.9
Relative Wind Speed	knots	1 Hz	3.1, 3.9
Relative Wind Direction	deg	1 Hz	3.1, 3.9
Weather Observations	-	Every 4 hours	3.13
Sea State	-	Every 4 hours	2.2, 3.13
Ocean Current	-	-	2.2
Wave Direction	deg (true)	Every 4 hours	2.2, 3.13
Wave Height	m	Every 4 hours	2.2, 3.13
Directional Wave Spectra	-	Every 30 min.[1]	2.2, 3.8
Ship Drafts	m	Start & End of Trial	Annex A, 3.13
Tank Volumes	-	Start & End of Trial	Annex B, 3.13
Load and Provisions	-	Start of Trial	Annex C, 3.13

[1] When buoy is deployed.

3.1 NDDS Logging

The Navigational Data Distribution System (NDDS) is used to provide various navigational and environmental data streams throughout the ship. DRDC Atlantic will connect a stand-alone data logging computer (laptop) to this system through a network connection located in the Chart Room.

The following data will be logged through port 14041:

a. `$P1MVW` - Relative wind port anemometer velocity and direction;

b. `$P3MVW` - Relative wind starboard anemometer velocity and direction;

c. `$GPZDZ` - Date and time;

d. `$GPGLL` - Latitude and longitude;

e. `$GPHDT` - Ship heading from gyro-compass

f. `$WIMTW` - Water temperature;

g. `$PAXDR` - Air temperature, pressure, and humidity;

h. `$GPVTG` - Ship speed over ground (SOG) and course over ground COG.

3.2 Ship Relative Position

Ship relative position is used to determine specific metrics required by the M/C trial agenda [5], such as the diameter of a turning circle. Acquired latitude and longitude data for each run will be converted to distance (in metres) travelled by the ship's C.G. on a flat 2D plane relative to the start of that run.

3.3 Water Density

ITTC-recommended procedures [1], [6] for ship trials require that the ocean water density be measured. This will be performed daily by testing a sample of sea water on-board ship using a sea water hydrometer (Aqua Medic® refractometer). This device uses light refraction to determine salinity against a temperature compensated scale. Water density measurements will be made daily during the trial.

3.4 IPMS Logging

The IPMS (also known as Halifax Class IPMS or HCI) will be used to access and log various data streams related to the machinery and propulsion systems during the trial.

The IPMS will be configured to log at its maximum rate (1 Hz) for the duration of the trial. At a minimum, the following data will be logged by IPMS and transferred to the DRDC trial team at the end of each day in an ASCII text format such as comma-delimited (.csv):

a. Shaft Rotations Per Minute (RPM) (port & starboard);

b. Propeller pitch setting (port & starboard);

c. GT Power Level Angle PLA port & starboard;

d. Shaft torque (port & starboard);

e. Shaft power (port & starboard);

f. Identification of engines in operations;

g. List of all running machinery, valve states, etc.

3.5 Motion Sensors

Ship motions will be recorded using DRDC Atlantic's motions sensor which will be temporary located in a passageway near the Chief and PO's servery during the trial; this is approximately the ship's centre of gravity. The data will be logged using a nearby laptop located in the Electrical Workshop. The sensor is a Crossbow® Nav420CA-100 [10] (specifications given in Table 4) which measures accelerations, angles, and angular rates along each of the three principal axes. Note that this sensor is subject to ITAR restrictions.

Table 4: NAV420 Specifications [10]

Description	Minimum Range	Minimum Accuracy	Minimum Resolution
Roll Angle	±90.0°	0.75° rms	0.1°
Pitch Angle	±45.0°	0.75° rms	0.1°
Yaw Angle	0°to 359.9°	0.75° rms	0.1°
Longitudinal Acceleration	±2.000 g	0.00075 g rms	0.001 g
Lateral Acceleration	±2.000 g	0.00075 g rms	0.001 g
Vertical Acceleration	±2.000 g (delta from Earth's)	0.00075 g rms	0.001 g

3.6 Time Synchronization

Conducting a sea trial with multiple independent data logging computers requires careful attention to time synchronization between the systems. Generally, the internal clocks used in most laptop and desktop computers stray over time (sometimes as much as seconds per day). To correct this, time servers are connected to each standalone computer or to groups of networked computers. Two brands of time servers will be used on this trial: the ORCA Model GS-101 [11], and the CNS Clock II [11].

These devices must first be synchronized with GPS time by connecting them to a GPS receiver. If they can maintain a connection to a GPS receiver, they will automatically stay synchronized. If however they cannot remain connected to a GPS, such as the case for several units on this trial, they will maintain time using very accurate internal clocks that can keep sub-millisecond precision for several months.

It is assumed that timestamps associated with ship's data (such as the IPMS and Navigational Data Distribution System (NDDS) systems) are accurate GPS time in UTC. This will be manually checked at the beginning and end of the trial.

3.7 ECPINS Logging

The DRDC trial team requests that it be given data from the ship's ECPINS for each day of the trial. The ECPINS system should be set to use the ship's commercial Raven GPS unit. This data, such as ship speed, location, etc. will serve as a backup set to similar data collected elsewhere (the NDDS should be streaming data from the ship's military Force 5 GPS). The data should be in a form readable by DRDC, such as formatted ASCII text (format descriptions should also be provided).

3.8 Sea State Measurement

Both the standardization and M/C trials require relatively mild sea conditions (see Section 2.2). It is therefore important to log the sea conditions throughout the trial. This will be done in several ways:

a. As part of the trial log (Section 3.13), visual estimation of sea state number, wave height, and wave direction shall be made and recorded in the trial log once per watch (every 4 hours) or more frequently in rapidly changing conditions.

b. If the ship is operating near a moored wave buoy (such as those operated by Environment Canada or NOAA), then this data will be collected post-trial.

c. Meteorological forecasts regarding sea conditions received during the trial shall be saved as part of the trial log (will require the ship to have internet access).

d. Data from a free floating directional wave buoy (if deployed).

The trial team will bring a free floating Triaxys^{TM} directional wave buoy on ship for the trial (see Figure 2, Table 5). A VHF receiver for the buoy will be located inside the ship's hanger with an antenna (temporarily) mounted outside at the top of the hanger or deck railing (see Figure 3). The receiver will be connected to a laptop computer running Triaxys WaveView software used to view sea state parameters as they are received from the buoy. Another laptop computer running charting software (Fugawi) will be used to track the buoy and ship locations. The buoy transmits its latitude and longitude every half hour which are then manually entered into the charting package. The ship's location will be tracked using a hand-held GPS unit (Garmin 72) connected to charting computer. The GPS's antenna will be mounted outside either on the top of the hanger or on the deck railing alongside the VHF antenna (final arrangement will be determined on-site). This set-up is illustrated in Figure 1.

This buoy measures the full directional sea spectrum every 30 minutes from which wave height, wave direction, and other parameters can be extracted. Data is stored in the buoy and is transmitted via VHF to the receiver on the ship. It is also possible to communicate with the buoy via satellite (requires an internet connection) should it get out of VHF range.

If conditions are sufficiently mild for the trial, the buoy will not be deployed. This is to avoid the necessity of having to return to the buoy location if trial patterns and buoy drift cause the ship to be too far away. If however, sea conditions are borderline or higher (SS>2), the buoy shall be deployed and trial operations performed within in it's VHF range.

Table 5: Triaxys Directional Wave Buoy Dimensions

Diameter	1.10 m (43.5 inches)
Outside bumper diameter	0.91 m (36 inches)
Weight	197 kg (435 lb)
Obstruction Light	Amber LED. Programmable ODAS flash sequence with three miles visibility.

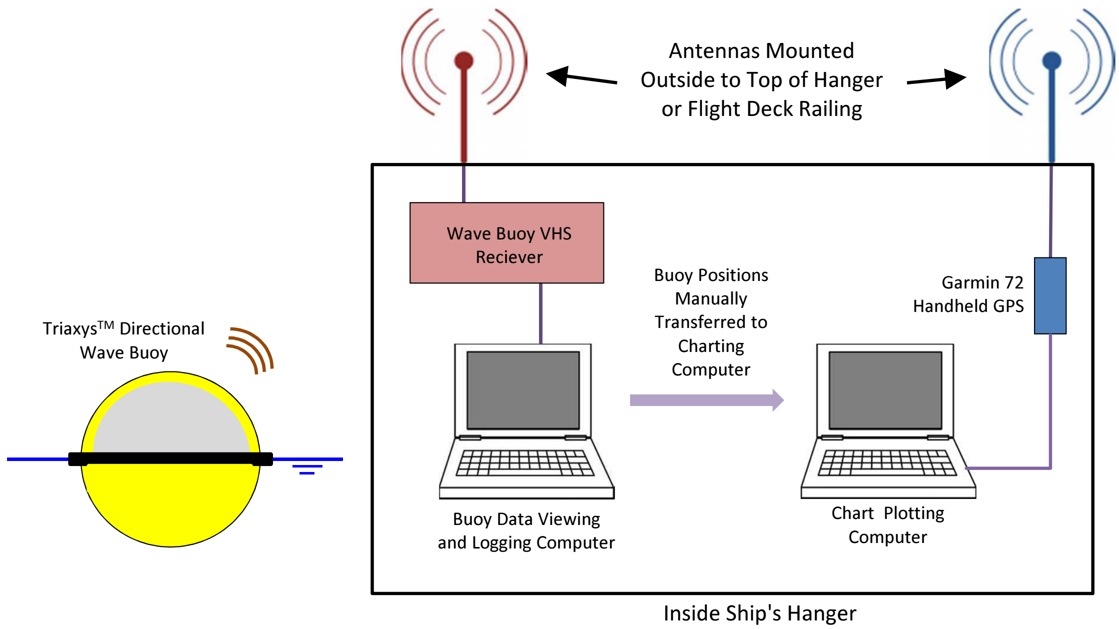

Figure 1: Wave Buoy Setup

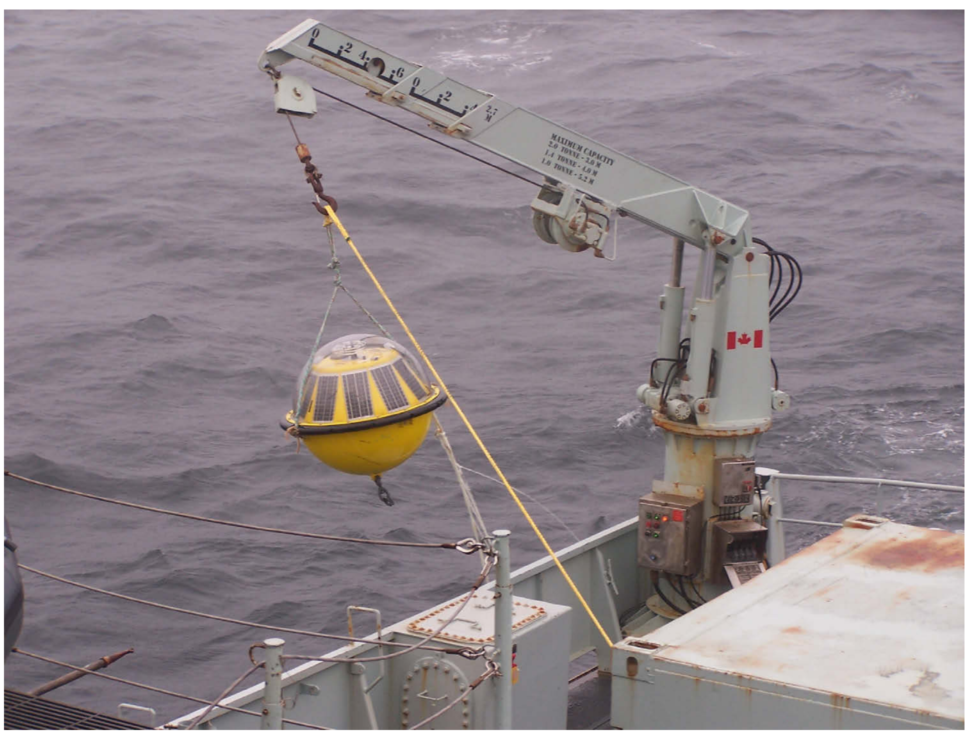

Figure 2: Recovery of Wave Buoy on HMCS KINGSTON

Figure 3: Aft Deck Equipment Locations

3.9 Supplementary Anemometers

Relative wind measurements shall be recorded using the ship's port and starboard anemometers located on the mast by logging the NDDS (Section 3.1).

In addition, the DRDC trial team will temporarily install two RM Young®Model 81000 ultrasonic anemometers at the bow. This data will used to support verification and validation activities related to ship airwake and helicopter operations.

The anemometers will be fitted to an aluminum pole, shown in Figure 4, designed to fit the mounts for the ship's flagstaff. They will be mounted at 3 m and 5 m above the deck. There is also a mounting location for the forward DGPS antenna (see Section 3.11). Cables from these sensors will lead back to a weatherproof enclosure (Pelican™ case) located outside on the bridge wing (see Figure 5). Also on the bridge top, there will be sensors for air temperature, air pressure, and relative humidity.

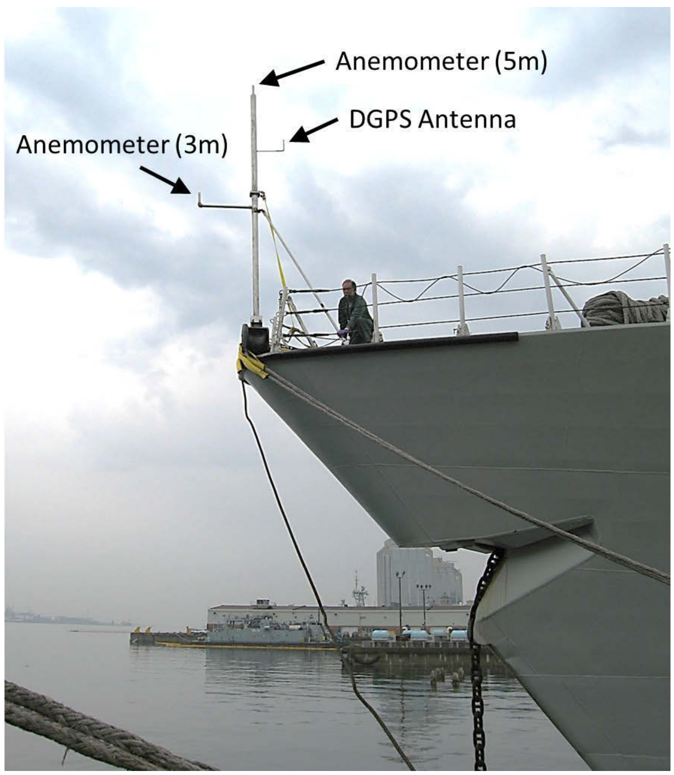

Figure 4: Bow Anemometer Pole

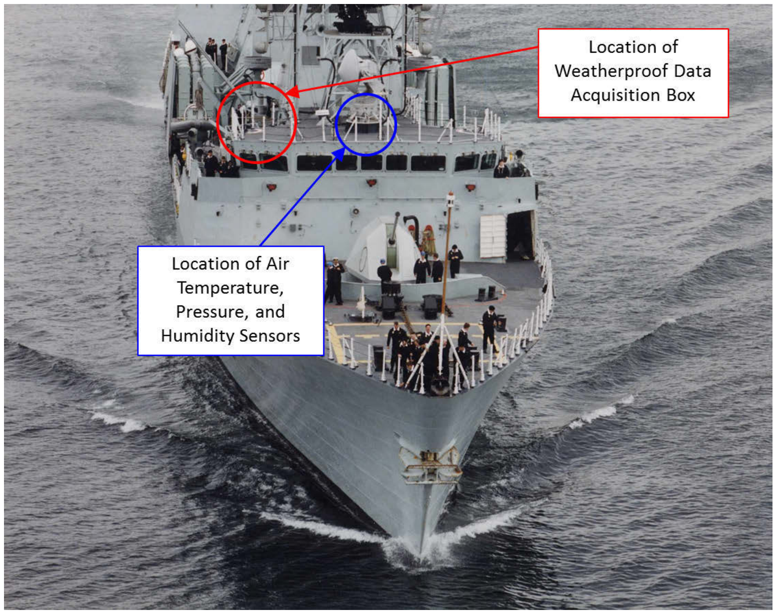

Figure 5: Bridge Top Equipment

3.10 Fuel Consumption

The Standardization Trial Agenda [4] states that fuel consumption is to be measured. Earlier in the planning phases of this trial it was expected that the IPMS would log fuel consumption using existing flow meters attached to the engine feeds. It was later determined that although the IPMS is capable of logging this data, the fuel meters were out of service on CALGARY and will not be functional for the trial.

In June 2013, it was decided that fuel meters would be installed by Naval Engineering Test Establishment (NETE) through a contract with DNPS 3-8. They will use Siemens FUP101 ultrasonic flow meters [12] attached to both GT fuel feeds, as well as to the PDE fuel feed and return lines. These are non-intrusive instruments that mount to the outside of a (preferably) straight length of piping. The sensor's output data is flow rate with a maximum sampling frequency of 0.2 Hz (every 5 seconds). This serial data output will be logged by DRDC acquisition computers co-located with each sensor. DRDC is not responsible for the installation or removal of the meters.

3.11 Differential GPS

In order to obtain the best possible accuracy for the ship position and orientation, a set of DGPS units will installed on the ship for the trial. The system consists of two dual-frequency GNSS receivers (Novatel FlexPak^{TM}-V2-L1) connected to ring-style antennas (Novatel GPS-701-GG). One set will be located on the anemometer bridge pole (see Section 3.9), and the other mounted on the aft rail of the quarterdeck (see Figure 3). Both units will be aligned with the centre-line of the ship. Data will be logged by a Raspberry Pi (Model-B Rev2) mini-computer encased in a watertight enclosure mounted near each unit (see Figure 6). Data collected by the units can be post-processed using Novatel's GrafMov software to potentially achieve relative precision between the two units (range and bearing) to within 20 cm.

Figure 6: Example Setup for DGPS Receiver, Antenna, and Logging System

3.12 Rudder Angle

Rudder angle is not logged on any of the ship's native systems. A custom set-up is therefore required for this trial.

Rudder angle will be measured and recorded by two identical stand-alone systems located in the steering gear compartment (primary and redundant backup). As illustrated in Figure 7, each system consists of a cable-extension transducer, an Analog/Digital (A/D) converter, and laptop computer. The base of the transducer will be fixed to a position near the top of the rudder stock. The transducer cable will attach to the rudder stock such that the cable is partially wrapped along the stock's outer perimeter. As the rudder changes angle, the cable will extend or retract an amount that is linearly proportional with the change in rudder angle. The transducers analog voltage output will pass through an A/D converter before being recorded on a laptop computer. Calibration parameters between transducer output voltage and rudder angle will be determined during pre-trial set-up and again at the end of the trial. Periodic checks of this system will be made during the trial by comparing rudder angle values given by the logging system and ship's system.

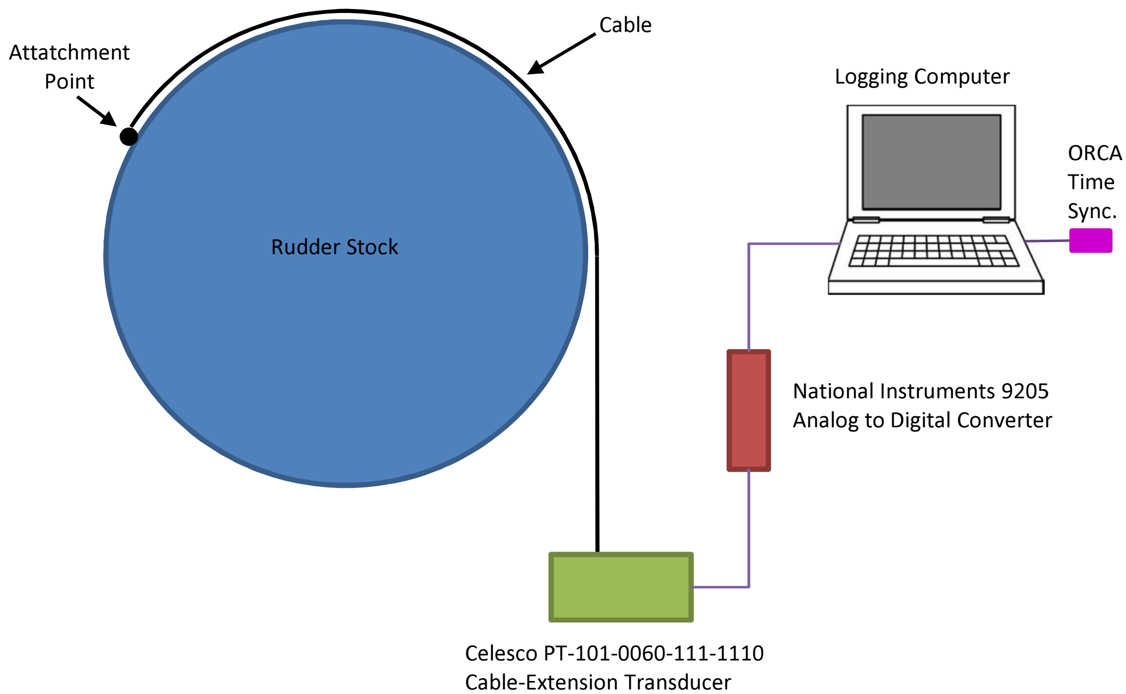

Figure 7: Rudder Angle Measurement Setup

3.13 Trial Log

A trial log shall be maintained by the DRDC trial team. It shall include the following:

- Load Items and Provisions Record Sheet, Annex A (start and end of trial)
- Tank Sounding Record Sheet, Annex B (start and end of trial)
- Ship Draughts Record Sheet, Annex C (start and end of trial)
- Ship GHS Load Monitor (GLM) reports [13] (once daily)
- Weather forecasts and observations (at least twice daily)
- Data on tides and ocean currents in operational area (as available)
- Visual estimates of sea state, wave height, wave direction (at least twice daily, including photos of sea where possible)

- Water density measurements (start and end of trial and once daily in operational area)
- Notes on operational issues related to the ship and data acquisition systems (as appropriate)
- Run logs including run start and end times, engine configuration, shafts operating, propeller pitch, ship speed, and other relevant parameters (per run).
- Notes on issues encountered during runs (as appropriate).

4 Standardization Trial

The objective of the standardization trial is to establish the relationship between ship speed, shaft torque, and RPM at the tested ship condition of draft and displacement by performing a series of "measured mile" runs. The information will be used to baseline performance of the HALIFAX class post-HCM/FELEX and to provide data for simulators [4].

4.1 Dead Drift Runs

Dead drift runs are used to determine the ambient drift the ship experiences due to environmental factors such as wind, waves, and current. These runs may be carried out periodically through the trial.

The dead drift runs shall be carried out as per the following procedure:

- Put ship in dead-in-water (zero speed) condition with rudder at midships. Propellers may be stopped, or rotating with pitch set for zero thrust.
- Start the run. Note 'Run Start' time in log.
- Maintain dead-in-water condition for 15 minutes. Allow ship to drift freely. No engine orders or rudder movements shall be issued for this period.
- End the run. Note 'Run End' time in log.

4.2 Slow Circle Drift Runs

Slow circle drift runs are another method used to determine the ambient drift the ship experiences due to environmental factors such as wind, waves, and current. The ship performs a steady turn at slow speed for two complete circles. These runs may be carried out periodically through the trial.

The slow circle drift runs shall be carried out using the same procedure as the turning circle manoeuvre (without a pull-out) described in Section 5.1 using a ship speed of 5 knots and a rudder angle of 5 degrees. At least two full circles must be completed before terminating the run.

4.3 Baseline Runs

Baseline runs are used to quickly gather data over a range of ship speeds to help identify potential issues with equipment and machinery. Ship speeds at 2 knot increments are set and held for 2 minutes each. Baseline runs will be conducted at the beginning and end of the trial for both ahead and astern speeds.

The baseline runs shall be carried out as per the following procedure:

- Set course into prevailing wind and waves.
- Set 'Zero Speed' with shafts rotating and pitch set for zero thrust. Note the 'Run Start' time and 'Initial Course' in the log.
- Hold for 2 minutes.
- Increase ship speed by 2 knots.
- Once ship achieves steady speed, hold course and speed for 2 minutes.
- Continue increasing speed in 2 knot increments for 2 minutes each up to maximum speed.
- End the run. Note run end time in log.

4.4 Measured Mile Runs

The measured mile runs (see Figure 8) will follow the same procedure as used on HMCS HALIFAX in 1991 [3]. A minimum of two runs will be conducted at each engine RPM setting along a primary course, a reverse course, and again along the primary course if required. The primary course will be into the prevailing wind and sea conditions. Reverse course will be 180 degrees with respect to the primary course. The engine configuration will be set as appropriate to the power required. The propellers will be set and maintained at design pitch angle (DPA) for all forward measured mile runs and design pitch angle reverse (DPAR) for all reverse speed runs. The vessel will be on manual steering for all runs.

The 22-33 measured mile runs are listed in Table 6 and are estimated to take approximately 11 hours to complete. Additional runs may be required depending on results and environmental conditions. It was noted during the 1991 trial [3] that obtaining RPM1 at the design pitch was challenging due to the high idle speed of the engines. For the current trial this shaft rate may be increased to the slowest safe speed (while maintaining design pitch).

The measured mile runs shall be carried out as per the following procedure:

- Establish steady running conditions for the given shaft RPM for a minimum of two minutes.
- Set course into prevailing wind and waves.

- When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.
- Once a steady course and speed are achieved, the power plant controls shall not be manipulated for the duration of the run.
- Maintain steady course and speed for 1-2 minutes.
- Note manoeuvre start time in log.
- Maintain a constant course (with manual steering) and speed for a least one nautical mile or a minimum of ten minutes[1] (see Table 7) of steady data collection (which ever is larger).
- End the run. Note run end time in log.
- If repeating run, perform Williamson turn with no more than 10° helm to reverse course.

Repeat runs will be performed if:

i. the difference in speed-over-ground between runs at the same engine settings is greater than 1 knot, or,

ii. there was a large rudder movement during the run (over 5°).

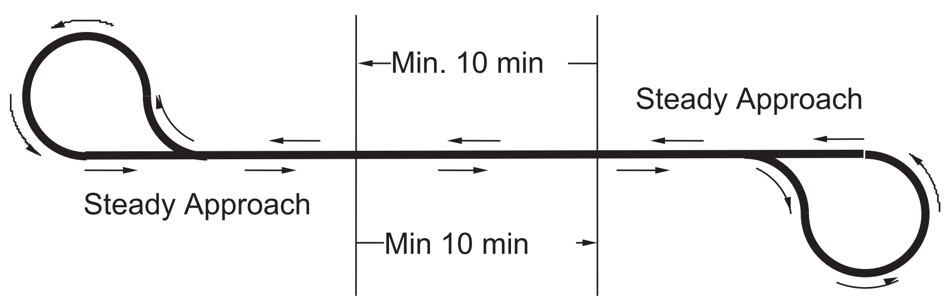

Figure 8: Measured Mile Run [1]

[1] Minimum run time of 10 minutes based on ITTC [1] (1991 trial [3] used 5 minutes, trial agenda [4] calls for 3 minutes).

Table 6: Measured Mile Run List

Nominal Shaft Speed [RPM]	Propeller Pitch [deg]	Engine Config.	Number of Runs
RPM1*	DPA	2GT	2-3
RPM2	DPA	2GT	2-3
RPM3	DPA	2GT	2-3
RPM4	DPA	2GT	2-3
RPM5	DPA	2GT	2-3
RPM6	DPA	2GT	2-3
RPM7	DPA	2GT	2-3
RPM8	DPA	2GT	2-3
RPM9	DPAR	2GT	2-3
RPM10	DPAR	2GT	2-3
RPM11	DPAR	2GT	2-3
RPM12	DPAR	2GT	2-3

*may be increased to lowest safe rate for machinery

Table 7: Time to Travel 1 Nautical Mile

Ship Speed [knots]	Time [min]	Ship Speed [knots]	Time [min]
2	30.0	18	3.3
4	15.0	20	3.0
6	10.0	22	2.7
8	7.5	24	2.5
10	6.0	26	2.3
12	5.0	28	2.1
14	4.3	30	2.0
16	3.8	32	1.9

4.5 Optional Measured Mile Runs

Time permitting, additional standardization runs will be carried out using alternate engine configurations (1GT, PDE) for comparison of fuel consumption rates.

5 Manoeuvring/Controllability Trial

The objective of the M/C trial is to document the manoeuvring/controllability characteristics of the Halifax class post HCM/FELEX refit. The trials will identify any significant changes that could impact the operations of the vessels and provide data that can be used for validation of computer simulations [5]. Unless otherwise indicated, the engine configuration used for manoeuvring runs may be 2GT for all runs, but may be reduced to 1GT for ahead speeds of 5-15 knots or astern speeds of 5 knots. Shaft RPM and propeller pitch shall be set by the IPMS for the given ship speeds.

5.1 Turning Circles

Turning circles will be performed for rudder angles and forward ship speeds as defined in Table 8 and for astern speeds as defined in Table 9. Red squares indicate circles performed with port rudder angle and green squares indicate circles performed with starboard rudder angle. Squares with "PO" indicate that the turning circle will terminate with a pull-out manoeuvre as described in Section 5.2.

In addition to turning circles in the standard configuration (using both shafts cross-connected), additional runs will be performed with a single powered shaft as indicated in Tables 8 and 9. The unpowered shaft shall be trailing as described in Section 2.3. Shaft rate and propeller pitch for each run will be in accordance with the IPMS schedule for the given ship speed. A single rudder pump will be used for all runs.

It is estimated that approximately 26 hours will be required to complete the set of forward speed turning circles, and 8 hours to complete the set of astern turning circles.

For analysis purposes, turning circles begin when the rudder order is given. This reference coordinate system has its origin at this point with the x-axis (advance) oriented with the approach course and the y-axis (transfer) perpendicular to the approach course. Various metrics shall be determined in post-trial analysis for each turning circle as described in Table 10 and Figure 9.

The turning circles shall be carried out as per the following procedure:

i. Set ship to required speed for run. Note the 'Engine Config.' in the log.

ii. Set course into prevailing wind and waves at assigned ship speed.

iii. When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.

iv. Once a steady course and speed are achieved, the power plant controls shall not be manipulated for the duration of the manoeuvre.

v. Maintain steady course and speed for 1-2 minutes.

vi. Order rudder over to required angle at maximum slew rate (one rudder pump active). Note the 'Manoeuvre Start' time in the log.

vii. No engine or propeller pitch order shall be given during the turns.

viii. Maintain rudder angle until ship has completed at least one and a half (540°) steady turns.

<u>If Run Does Not Include a Pull-Out Test</u>

ix. End the run and note 'Run End' time in the log.

<u>If Run Includes a Pull-Out Test</u>

x. Perform Pull-Out Test (see Section 5.2). Order rudder to midships at maximum slew rate (one rudder pump active). Note 'Pullout Start' time in the log.

xi. Wait until ship achieves a steady course and continue for 1-2 minutes.

xii. End the run and note 'Run End' time in the log.

Table 8: Ahead Turning Circles

Both Shafts Powered

Speed	Port Rudder Angle							Starboard Rudder Angle						
[knots]	35°	30°	25°	20°	15°	10°	5°	5°	10°	15°	20°	25°	30°	35°
5	PO					PO			PO					PO
10					PO					PO				
15				PO							PO			
20			PO									PO		
25		PO											PO	
Max	PO						PO	PO						PO

Only Port Shaft Powered

5														
10														

Only Starboard Shaft Powered

5														
10														

Table 9: Astern Turning Circles

Both Shafts Powered

Speed	Port Rudder Angle							Starboard Rudder Angle						
[knots]	35°	30°	25°	20°	15°	10°	5°	5°	10°	15°	20°	25°	30°	35°
5														
10														

Only Port Shaft Powered

5														
10														

Only Starboard Shaft Powered

5														
10														

Table 10: Turning Circle Metrics

Item	Description
Approach Course	Steady straight course ship was on prior to executing turning circle manoeuvre.
Approach Speed	Steady speed of ship prior to executing turning circle manoeuvre.
Rudder Angle	Rudder angle ordered to begin manoeuvre.
Rudder Execute	Turning circle begins when rudder is called to desired angle at full slew rate. This is the reference point for advance (x) and transfer (y) coordinates.
t_{090}	Time taken to reach 90°change of heading. Times for each 90°change of heading shall be reported.
x_{090}	Advance at 90°change of heading. Advance values for each 90°change of heading shall be reported.
x_{Max}	Maximum advance.
y_{090}	Transfer at 90°change of heading. Transfer values for each 90°change of heading shall be reported.
y_{180}	Transfer at 180°change of heading. This is also referred to as the tactical diameter.
y_{Max}	Maximum transfer.
R_C	Steady turning radius.
β_C	Drift angle (the difference between ship's heading and course over ground).
v_{Loss}	Loss of forward speed during the turn.
ROT	Rate of turn.

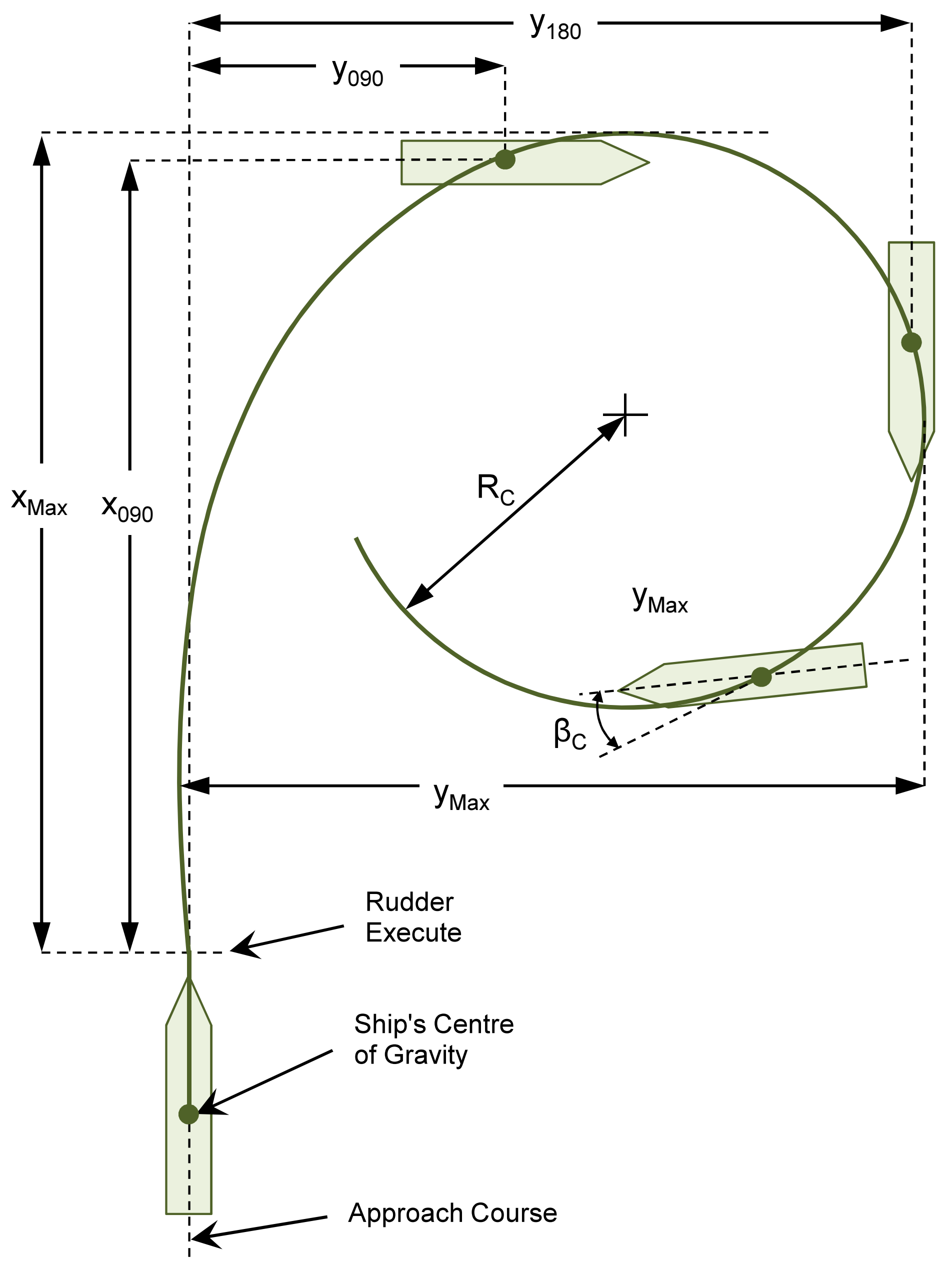

Figure 9: Turning Circle Diagram

5.2 Pullout Tests

The pullout manoeuvre is a simple test that can give an indication of a ship's course stability. The ship is first put into a steady turn and then the rudder is returned to midships. If the ship is directionally stable, then the yaw rate will decay to zero. Otherwise it will decay to some non-zero residual value.

Pullout tests for this trial will be conducted at the end of certain turning circle runs (Section 5.1) as indicated in Table 8. The turning circle manoeuvre ends with the ship in a steady turn, at which point the rudder shall be returned to amidships and the rate of turn shall be allowed to decay with the rudder held at amidships.

Analysis of the pullout test data shall include a listing of approach speeds, rudder angles, resulting times to decay, and final yaw angles. Plots of yaw rate time histories of each pullout test shall be generated such as shown in Figure 10.

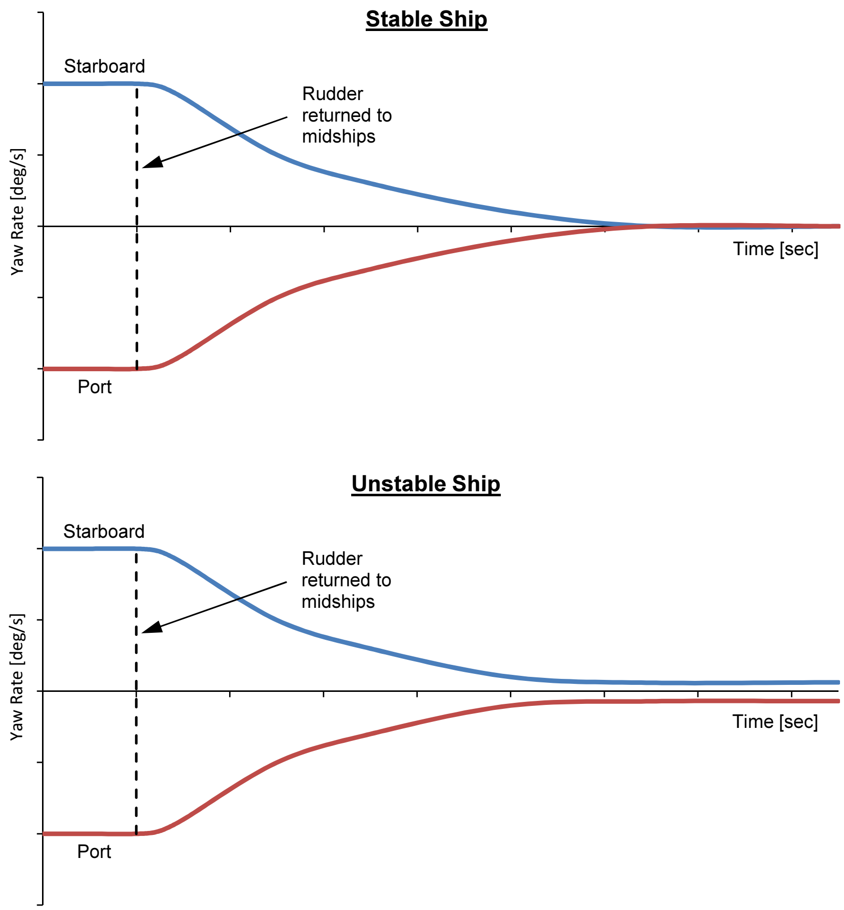

Figure 10: Example Pullout Yaw Rate Time Histories

5.3 Zigzag Manoeuvres

The zigzag manoeuvre is performed by reversing the rudder angle to δ degrees each time the ship's heading deviates from its original course by a specified helm angle, ψ. This is done alternately from port to starboard causing the ship's course to zigzag along its original line of travel.

A list of the zigzag manoeuvres that will be performed for this trial is given in Table 11. It is estimated that approximately 5 hours will be required to complete this set of runs.

The resulting data from zigzag manoeuvres will be analyzed to determine various metrics as described in Figure 11 and Table 12.

The zigzag manoeuvres shall be carried out as per the following procedure (all rudder movements carried out at the maximum slew rate with one rudder pump active):

i. Ensure the current engine configuration is suitable for the required run speed. Note the 'Engine Config.' in the log.

ii. Set course into prevailing wind and waves at assigned ship speed.

iii. When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.

iv. Once a steady course and speed are achieved, the power plant controls shall not be manipulated for the duration of the manoeuvre.

v. Maintain steady course and speed for 1-2 minutes.

vi. Note the '1st Turn' time in the log. Turn to be made to port or starboard as indicated in Table 11. Move the rudder from centre to δ degrees and hold until ship's heading changes by ψ degrees from direction of the original course.

vii. Note the '1st Reverse Turn' time in the log. Move the rudder directly to δ degrees in the opposite direction and hold until ship's heading is $-\psi$ degrees from of the original course (i.e. heading will change by twice $\sim\psi$ degrees).

viii. Note the '2nd Turn' time in the log. Move the rudder to δ degrees in the opposite direction and hold until ship's heading is ψ degrees from of the original course.

ix. Note the '2nd Reverse Turn' time in the log. Move the rudder to δ degrees in the opposite direction and hold until ship's heading is $-\psi$ degrees from of the original course.

x. Note the '3rd Turn' time in the log. Move the rudder to δ degrees in the opposite direction and hold until ship's heading is ψ degrees from of the original course.

xi. Note the '3rd Reverse Turn' time in the log. Move the rudder to δ degrees in the opposite direction and hold until original heading is restored.

xii. End the manoeuvre. Note the 'Run End' time in the log.

In most cases for this trial, helm orders for manoeuvres from the DRDC trial team could be given to the Officer of the Watch (OOW), who could then relay them to the helmsman for execution. This introduces a small lag time that would not affect most runs, but would affect the zigzag manoeuvres. It is essential that the helmsman be able to react quickly and execute rudder movements when ship heading reaches the target values to properly perform a zigzag manoeuvre. The communication protocol between DRDC trial team and ship crew for these runs should accommodate this requirement.

Table 11: Zigzag Maneouvre List

Speed [knots]	Manoeuvre	Rudder Angle, δ	Yaw Angle, ψ	First Turn
10	10°/10°	10°	10°	Port
10	20°/20°	20°	20°	Port
15	10°/10°	10°	10°	Port
15	20°/20°	20°	20°	Port
15	20°/20°	20°	20°	Stbd
20	10°/10°	10°	10°	Port
20	10°/10°	10°	10°	Stbd
20	20°/20°	20°	20°	Port
20	20°/20°	20°	20°	Stbd
25	10°/10°	10°	10°	Port
25	20°/20°	20°	20°	Port
25	20°/20°	20°	20°	Stbd.
30	10°/10°	10°	10°	Port
30	20°/20°	20°	20°	Port

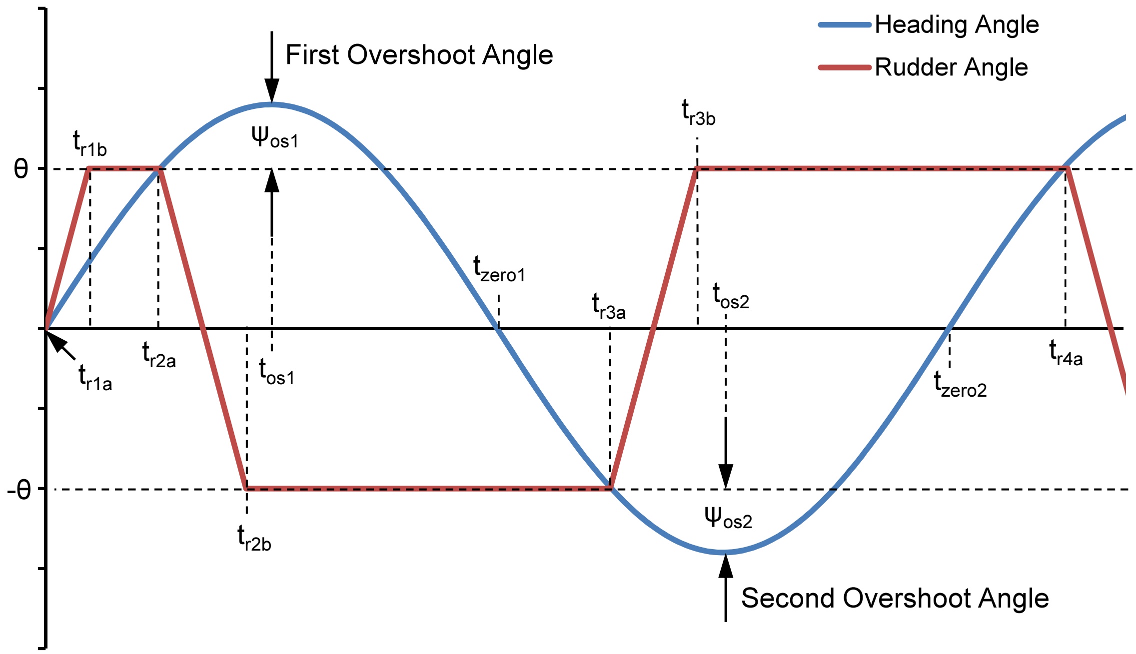

Figure 11: Zigzag Manoeuvre Diagram

Table 12: Zigzag Manoeuvre Metrics

Item	Description
Approach Course	Steady straight course ship was on prior to first rudder execute.
Approach Speed	Steady speed of ship prior to executing first rudder execute.
Rudder Angle	Rudder angle ordered at each execute.
Yaw Angle	Amount of yaw to signal reverse rudder angle execute.
t_{ria}	Times of rudder executes. The is the time when the rudder is ordered to the specified angle.
t_{rib}	Times when the rudder reaches specified angle after execute.
t_{osi}	Times when ship reaches maximum overshoot angle after an execute.
t_{zeroi}	Times when the ship returns to its original heading after an execute.
t_{r2a}	Initial turning time. Time to reach helm angle after first rudder execute.
ψ_{osi}	Overshoot angles for each turn. This is the angle through which the ship continues to turn in the original direction after the application of counter rudder.
t_{reachi}	The time between an execute and the instant when the ship's heading is zero after the next execute. e.g. $t_{reachi} = t_{zeroi} - t_{ria}$
$T_{r2\text{-}4}$	Time from the second to fourth rudder execute. e.g. $T_{ex2\text{-}4} = t_{r4a} - t_{r2a}$
$L_{r2\text{-}4}$	Distance (in ship lengths) the ship travels along its original course from the second to fourth execute.

5.4 Optional Zigzag Manoeuvres

Time permitting, additional zizag manoevres will be conducted as listed in Table 13.

Table 13: Optional Zigzag Maneouvre List

Speed [knots]	Manoeuvre	Rudder Angle, δ	Yaw Angle, ψ	First Turn
10	15°/15°	15°	15°	Port
10	30°/30°	30°	30°	Port
15	15°/15°	15°	15°	Port
15	15°/15°	15°	15°	Stbd
15	30°/30°	30°	30°	Port
20	15°/15°	15°	15°	Port
20	30°/30°	30°	30°	Port
20	30°/30°	30°	30°	Stbd
25	15°/15°	15°	15°	Stbd
25	30°/30°	30°	30°	Stbd
30	15°/15°	15°	15°	Stbd
30	30°/30°	30°	30°	Port
30	30°/30°	30°	30°	Stbd

5.5 Direct Spiral Manoeuvres

Spiral manoeuvres are used to assess course stability of a ship. They are performed by putting the ship into a steady turn and incrementally altering the rudder angle and holding it until the new turn becomes steady.

Three full direct spiral manoeuvres will be performed on the trial, one each for ship speeds of 10, 20, and 30 knots. This set of runs is estimated to take 7.5 hours.

Analysis of the direct spiral data shall include tabulated results of the constant yaw angles and associated rudder settings for each ship speed as well as plots such as shown in Figure 12.

The direct spiral manoeuvre shall be carried out as per the following procedure:

i. Ensure the current engine configuration is suitable for the required run speed. Note the ‘Engine Config.’ in the log.

ii. Set course into prevailing wind and waves at assigned ship speed.

iii. When ship is at steady course and speed, note the ‘Run Start’ time and ‘Initial Course’ in the log.

iv. Once a steady course and speed are achieved, the power plant controls shall not be manipulated for the duration of the manoeuvre.

v. Maintain steady course and speed for 1-2 minutes.

vi. The rudder is ordered to 25°starboard (all rudder orders are at maximum slew rate) and held until the turning rate becomes steady for at least 1 minute. Note the time of the rudder execute in the log.

vii. The rudder is ordered to the following settings and held at each setting until a steady turning rate maintains a constant value for approximately 1 minute. The times for each rudder execute shall be noted in the log.

$20°S \rightarrow 15°S \rightarrow 10°S \rightarrow 5°S \rightarrow 3°S \rightarrow 1°S \rightarrow 0° \rightarrow$

$1°P \rightarrow 3°P \rightarrow 5°P \rightarrow 10°P \rightarrow 15°P \rightarrow 20°P \rightarrow 25°P \rightarrow$

$20°P \rightarrow 15°P \rightarrow 10°P \rightarrow 5°P \rightarrow 3°P \rightarrow 1°P \rightarrow 0° \rightarrow$

$1°S \rightarrow 3°S \rightarrow 5°S \rightarrow 10°S \rightarrow 15°S \rightarrow 20°S \rightarrow 25°S$

viii. Maintain the last rudder angle until the turning rate becomes steady for at least 1 minute. End the manoeuvre and note the ’Run End’ time in the log.

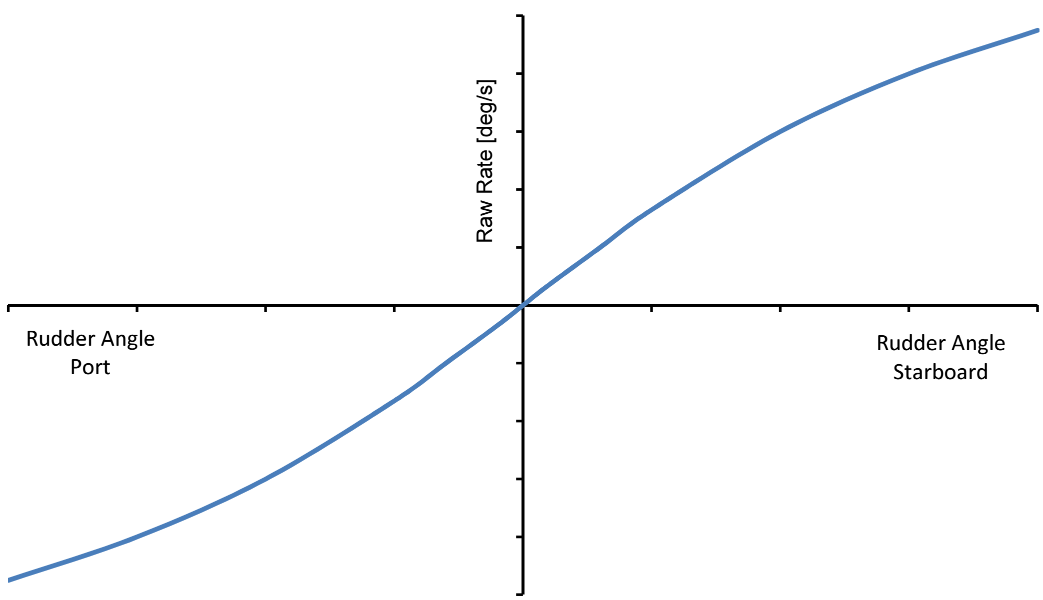

Figure 12: Example Direct Spiral Result (Directionally Stable Ship)

5.6 Slow Speed Controllability

These manoeuvres are used to determine the thresholds for controllability of the ship at slow speeds where rudder forces diminish.

Six ahead speed tests will be conducted starting from 6 knots reducing in 1 knot increments to 1 knot (or to when the ship becomes unresponsive). A single astern speed test will be conducted covering a range of speeds as described below.

Analysis of the test data will include a tabulated summary of the lateral position deviations and heading deviations for each run. It is estimated that this set of runs will take approximately 1.5 hours.

The ahead slow speed controllability test shall be carried out as per the following procedure:

i. Ensure the current engine configuration is suitable for the required run speed. Note the 'Engine Config.' in the log.

ii. Set course into prevailing wind and waves at assigned ship speed.

iii. When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.

iv. Once a steady course and speed are achieved, the power plant controls shall not be manipulated for the duration of the manoeuvre.

v. Maintain steady course and speed for 1-2 minutes.

vi. The following quasi-zigzag manoeuvres will be performed. Times for each rudder execute shall be noted in the log.

   a. Move the rudder to 20°S and hold for 30 seconds.
   b. Move the rudder to 20°P and hold for 30 seconds.
   c. Move the rudder to 0° and hold for 30 seconds.
   d. Return to the base course and adjust speed to required run speed with rudder at 0°.
   e. Move the rudder to 35°S and hold for 30 seconds.
   f. Move the rudder to 35°P and hold for 30 seconds.
   g. Move the rudder to 0° and hold for 30 seconds.
   h. Return to the base course.

vii. End the manoeuvre and note the 'Run End' time in the log.

This manoeuvre will be repeated with the speed decreased at 1 knot intervals (from 6 knots) until the speed at which the ship does not respond in a controlled and consistent manner to the helm is determined.

The astern slow speed controllability test shall be carried out as per the following procedure:

i. Ensure the current engine configuration is suitable for the required run speed. Note the ‘Engine Config.’ in the log.

ii. Set course astern into prevailing wind and waves at 6 knots.

iii. When ship is at steady course and speed, note the ‘Run Start’ time and ‘Initial Course’ in the log.

iv. Maintain steady course and speed for 1-2 minutes.

v. Decrease the ship speed by 1 knot intervals until the speed at which the ship does not respond in a controlled, predicted, and consistent manner is determined. Note the time of each speed decrease in the log and comment on the degree of controllability at each speed.

vi. End the manoeuvre and note the ’Run End’ time in the log.

5.7 Acceleration & Coasting Runs

These tests are used to assess the acceleration capabilities of the ship both from a dead stop and from a constant speed, v_{cruise} (meant to be the normal cruising speed the ship uses when there is no urgency). Discussions with operators indicate that this is 12 knots for the HALIFAX Class.

Analysis results for the acceleration component of the runs will include tabulated data on times and distances required to reach the set speeds along with plotted data showing any lateral drift from the set course.

These tests will also be used to assess the characteristics of the ship to coast to a complete stop from a given initial steady speed when propulsive power from the propellers is suddenly removed.

Analysis results for the deceleration component of the runs will include tabulated data on times and distances needed to come to a complete stop along with plotted data showing any lateral drift from the set course.

Eleven runs will be performed for initial and final speeds as outlined in Table 14. It is estimated that this set of runs will take approximately 4 hours.

The acceleration/coasting runs shall be carried out as per the following procedure:

i. The ship shall be brought to the initial speed for the run and held on a straight steady course into prevailing wind and waves. If the initial speed is 0 knots ("dead-in-water" condition), the propeller pitch and RPM will be set by the IPMS for zero speed.

ii. When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.

iii. Maintain initial speed condition for at least 2 minutes.

iv. An engine order for the final speed shall be executed for maximum authorized power at the maximum acceleration rate, while maintaining rudder at amidships, until the final speed is achieved. Throttles/propeller pitch settings shall be set at the maximum rate in accordance with the IPMS's schedule, and the settings shall be maintained until the ship reaches the new steady state. Note the 'Accel Start' time in the log.

v. The ship shall be assumed to have reached and maintained the final speed when the bridge speed log indicates no significant change in speed over a period of at least 30 seconds. The run will continue at this steady speed for at least 2 minutes.

vi. The engines will then be 'tripped' so that power to the propeller shafts will be shut off. Propeller pitch will remain at last setting and shaft RPM will decay to zero. Note the 'Decel. Start' time in the log.

vii. The ship will be allowed to coast to a complete stop.

viii. The ship will then be allowed to drift (after it has come to a stop) for approximately 5 minutes (needed for drift correction).

ix. End the run and note the 'Run End' time in the log.

x. If environmental conditions are such that they may affect the ship's acceleration/deceleration, then a repeat run shall be performed at a course 180 degrees to the initial course.

Table 14: Acceleration & Coasting Runs

Direction	Engine Config.	Initial Speed [knots]	Max. Speed [knots]	Coast Method
Ahead	2GT	0	5	Trip Engines
Ahead	2GT	0	10	Trip Engines
Ahead	2GT	0	15	Trip Engines
Ahead	2GT	0	20	Trip Engines
Ahead	2GT	0	25	Trip Engines
Ahead	2GT	0	30	Trip Engines
Ahead	2GT	0	v_{max}	Trip Engines
Ahead	2GT	$(v_{cruise} - 5) = 7$	v_{max}	Trip Engines
Ahead	2GT	$v_{cruise} = 12$	v_{max}	Trip Engines
Ahead	2GT	$(v_{cruise} + 5) = 17$	v_{max}	Trip Engines
Astern	2GT	0	v_{max_astern}	Trip Engines

5.8 Optional Acceleration & Coasting Runs

Time permitting, additional acceleration/coasting runs will be performed using alternate engine configurations for the acceleration as well as a different approach to coasting. Whereas the previous runs tripped the engines (thereby disengaging power to the shafts) to cease thrust, these runs will call for 'zero speed'. In this case propeller pitch will be set for zero thrust and shaft rates will reduce to the minimum safe rate of about 50 RPM.

Fourteen runs will be performed for initial and final speeds as outlined in Table 15. It is estimated that this set of runs will take approximately 5.5 hours.

The optional acceleration/coasting runs shall be carried out as per the following procedure:

i. The ship shall be brought to the initial speed for the run and held on a straight steady course into prevailing wind and waves. If the initial speed is 0 knots ("dead-in-water" condition), the propeller pitch and RPM will be set by the IPMS for zero speed.

ii. When ship is at steady course and speed, note the 'Run Start' time and 'Initial Course' in the log.

iii. Maintain initial speed condition for at least 2 minutes.

iv. An engine order for the final speed shall be executed for maximum authorized power at the maximum acceleration rate, while maintaining rudder at amidships, until the final speed is achieved. Throttles/propeller pitch settings shall be set at the maximum rate in accordance with the IPMS's schedule, and the settings shall be maintained until the ship reaches the new steady state. Note the 'Accel Start' time in the log.

v. The ship shall be assumed to have reached and maintained the final speed when the bridge speed log indicates no significant change in speed over a period of at least 30 seconds. The run will continue at this steady speed for at least 2 minutes.

vi. If Table 15 indicates 'None' for the 'Coast Method' for this run, then proceed to step x.

vii. A 'zero speed' order will be given. Note the 'Manoeuvre Start' time in the log. Pitch will be set for zero thrust and shafts will slow to the minimum safe rate (~50 RPM). Note the 'Decel. Start' time in the log.

viii. The ship will be allowed to coast to a complete stop.

ix. The ship will then be allowed to drift (after it has come to a stop) for approximately 5 minutes (needed for drift correction).

x. End the run and note the 'Run End' time in the log.

xi. If environmental conditions are such that they may affect the ship's acceleration/deceleration, then a repeat run shall be performed at a course 180 degrees to the initial course.

Table 15: Optional Acceleration & Coasting Runs

Direction	Engine Config.	Initial Speed [knots]	Max. Speed [knots]	Coast Method
Ahead	2GT	0	v_{max}	'Zero Speed' Call
Astern	2GT	0	v_{max_astern}	'Zero Speed' Call
Ahead	1GT	0	5	'Zero Speed' Call
Ahead	1GT	0	10	'Zero Speed' Call
Ahead	1GT	0	15	'Zero Speed' Call
Ahead	1GT	0	20	'Zero Speed' Call
Ahead	1GT	0	25	'Zero Speed' Call
Ahead	1GT	0	v_{max}	'Zero Speed' Call
Astern	1GT	0	v_{max_astern}	None
Ahead	PDE	0	5	None
Ahead	PDE	0	10	None
Ahead	PDE	0	15	None
Ahead	PDE	0	v_{max}	None
Astern	PDE	0	v_{max_astern}	None

5.9 Crash Stops

These tests are used to assess the capabilities of the ship to come to a complete stop from steady ahead speed using full astern power. This test is also referred to as; crash astern, crash stop, and crash back.

Analysis results will include tabulated data on times and distances needed to come to a complete stop along with plotted data showing any lateral drift from the set course. Four runs will be performed as indicated in Table 16. It is estimated that this set of runs will take approximately 1.5 hours.

Table 16: Crash Stop Tests

Initial Speed [knots]	Final Speed [knots]	Engine Config.
v_{max}	0	2GT
$(v_{cruise} - 5) = 7$	0	2GT
$v_{cruise} = 12$	0	2GT
$(v_{cruise} + 5) = 17$	0	2GT

The full power reversal tests shall be carried out as per the following procedure:

i. Set course into prevailing wind and waves at assigned ship speed.

ii. When ship is at steady course and speed, note the ‘Run Start’ time and ‘Initial Course’ in the log.

iii. Maintain steady course and speed for 1-2 minutes.

iv. The engine order ‘full astern’ on both shafts shall be executed for maximum authorized power at the maximum rate while maintaining rudder at amidships. Propeller pitch settings shall be fully reversed at the the maximum rate. Note the ‘Manoeuvre Start’ time in the log.

v. Once the ship has slowed to zero speed and started to reverse direction, the ‘zero speed’ order shall be executed for both shafts.

vi. The ship will then be allowed to drift (after it has come to a stop) for approximately 5 minutes (needed for drift correction).

vii. End the run and note the ’Run End’ time in the log.

viii. If environmental conditions are such that they may affect the ship’s deceleration, then a repeat run shall be performed at a course 180 degrees to the initial course.

5.10 Speed Reversals

These tests are used to assess the capabilities of the ship to completely reverse direction using full power.

Analysis results will include tabulated data on times and distances needed to reverse speed along with plotted data showing any lateral drift from the set course. Four runs will be performed as indicated in Table 17. It is estimated that this set of runs will take approximately 1.5 hours.

The full power reversal tests shall be carried out as per the following procedure:

i. Set course into prevailing wind and waves at assigned ship speed.

ii. When ship is at steady course and speed, note the ‘Run Start’ time and ‘Initial Course’ in the log.

iii. Maintain steady course and speed for 1-2 minutes.

Table 17: Speed Reverse Tests

Initial Speed [knots]	Final Speed [knots]	Engine Config.
v_{max}	v_{max_astern}	2GT
$v_{cruise} - 5 = 7$	v_{max_astern}	2GT
$v_{cruise} - 12$	v_{max_astern}	2GT
$v_{cruise} + 5 - 17$	v_{max_astern}	2GT
v_{max_astern}	v_{max}	2GT

iv. The engine order ‘full astern’ or ‘full ahead’ (as appropriate to the run) on both shafts shall be executed for maximum authorized power at the maximum rate while maintaining rudder at amidships. Propeller pitch settings shall be fully reversed at the maximum rate.

v. Final maximum speed is achieved when no significant change in speed is observed for a period of 30 seconds.

vi. The ship will then run at this maximum speed for 1-2 minutes.

vii. End the run and note the ’Run End’ time in the log.

viii. If environmental conditions are such that they may affect the ship’s deceleration/acceleration, then a repeat run shall be performed at a course 180 degrees to the initial course.

5.11 Optional Speed Reversals

Time permitting, additional speed reversal runs will be performed to assess the acceleration/deceleration profiles of alternate engine configurations. Additional runs will be performed as indicated in Table 18 using the same procedure as described in Section 5.10.

Table 18: Speed Reverse Tests

Initial Speed [knots]	Final Speed [knots]	Engine Config.
Max Ahead*	Max Astern*	1GT
$v_{cruise} - 5 = 7$	Max Astern*	1GT
$v_{cruise} = 12$	Max Astern*	1GT
$v_{cruise} + 5 = 17$	Max Astern*	1GT
Max Astern*	Max Ahead*	1GT
Max Ahead*	Max Astern*	PDE
$v_{cruise} - 5 = 7$	Max Astern*	PDE
$v_{cruise} = 12$	Max Astern*	PDE
$v_{cruise} + 5 = 17$	Max Astern*	PDE
Max Astern*	Max Ahead*	PDE

*maximum safe speed for given engine configuration

6 Schedule

This trial is planned to take place on HMCS CALGARY during a seven day window leaving Esquimalt dockside on Monday 09-Sep-2013 to be back alongside no later than the morning of Monday 16-Sep-2013. This trial window will be shared with two other trials' teams each conducting their own work. Time during the sea days for trial activities will be divided among the various teams as appropriate. A tentative schedule for activities related to this trial is given in Table 20. Blocks of time each day are committed to this trial or for Other Trials' Activities (OTA). These are subject to change in response to conditions on site.

The trial team will consist of the five people listed in Table 19; four from DRDC Atlantic, and one from DGMEPM Ottawa. Required equipment will be shipped from DRDC Atlantic to DRDC Dockyard Pacific in August 2013. The trial team will travel to Victoria on Thursday 05-Sep-2013. Equipment will be checked and prepared at DRDC Dockyard Pacific beginning the morning of Friday 06-Sep-2013. A security (COMSEC) check/ accreditation of trial data acquisition kit and associated computers will be performed by BIS staff that afternoon[2]. The ship is due to be alongside at 16:00 (local time) at which point the wave buoy will be loaded by crane to the boat deck, and the pallets containing DRDC trial kit will be loaded into the hanger. The flag staff at the bow must also be removed to make place for the anemometer pole (Section 3.9).

Saturday 07-Sep-2013 and Sunday 08-Sep-2013 will be used to install, set up, and test the data acquisition kit for the trial. It is not expected that the trial team will require any special assistance from ship crew for this set-up other than access to potentially locked spaces. The NDDS system must be active with required feeds (Section 3.1) for at least on few hours on Saturday afternoon or Sunday for acquisition tests.

Prior to departure on Monday 09-Sep-2013, the rudder angle acquisition system (Section 3.12) will be calibrated by moving the rudder through a series of set angles. This should take less than 30 minutes to complete. Departure drafts (Annex A) must be measured directly. Departure data for the Tank Soundings Record (Annex B, GLM report may be sufficient) and Load Provisions Record (Annex C) must be supplied by ship crew.

After transiting to the WCFA, Monday 09-Sep-2013 to Thursday 12-Sep-2013 will be used for trial activities as listed in Table 20. Runs will be performed as appropriate for the day's conditions. At least once per day, ship crew will provide trial team with data on ship loading (drafts, C.G., etc.), weather and sea state predictions, as well as the previous day's ECPINS, and IPMS data.

Other trials' activities should be completed by Friday 13-Sep-2013 at which time other

[2]It is also a possibility that the COMSEC inspection could be performed on Saturday 07-Sep-2013 once the kit is installed on CALGARY.

trials' staff may be transferred by boat to Tofino. The remainder the ship time on Friday 13-Sep-2013 to Sunday 15-Sep-2013 is dedicated to this trial. The ship may return early to Esquimalt if trial runs are completed, but must be alongside no later than Monday morning 16-Sep-2013.

Once alongside the return drafts (Annex A) must be measured directly. Return data for the Tank Soundings Record (Annex B) and Load Provisions Record (Annex C) must be supplied by ship crew along with any other outstanding data sets as described in Section 3. The wave buoy and all DRDC kit will be un-installed and removed. DRDC trial team then disembarks. DRDC kit will be re-packed at DRDC Dockyard Lab Pacific for return shipment to DRDC Atlantic. All computer hard drives will be removed from laptops. These and other related media will be transported back to DRDC Atlantic in person with DRDC staff. The DRDC trial team makes return travel to Halifax on Tuesday 17-Sep-2013.

The trial runs are estimated to take approximately 66 hours with additional optional runs of 24.5 hours for a combined total of 90.5 hours (Table 21). Note that this does not take into account times needed for transits to/from operational area, resetting between runs, spoiled runs, launch & recovery of wave buoy, or transiting within the operational area.

Should the trial runs not be completed during the assigned trial window (due to excessive weather conditions or essential equipment failure, etc.), the DRDC trial team and kit will remain on board ship for the following week (Monday 16-Sep-2013 to Friday 20-Sep-2013) and runs will be performed when possible in conjunction with other trials' activities.

Analysis of data set and final report will be completed no later than 31-Mar-2014.

Table 19: Trial Team

Name	Position	Location
Eric Thornhill (Trial Lead)	Defence Scientist	DRDC Atlantic
Matthew Cleary	Lieutenant (Navy)	DMSS 2-3-2 ADM(Mat) DGMEPM
Alex Ritchie	Engineering Technologist	DRDC Atlantic
Jim van Spengen	Computer Scientist	DRDC Atlantic
Roger Arsenault	Engineering Technologist	DRDC Atlantic

Table 20: Trial Schedule

Date	Activities
August 2013	DRDC equipment shipped to Dockyard Lab Pacific (Esquimalt).
Thursday 05 Sept 2013	DRDC trial team travels from Halifax to Victoria.
Friday 06 Sept 2013 0800:1700	DRDC prepares kit ashore. COMSEC inspection of kit. When ship comes alongside in afternoon, wave buoy will be loaded by crane to boat deck. DRDC equipment pallets will be loaded to hanger. Flag staff at bow must be removed.
Saturday 07 Sept 2013 0800:1700	Installation of DRDC kit on ship.
Sunday 08 Sept 2013 0800:1700	Installation/testing of DRDC kit on ship. Testing will require that NDDS system is active with required data feeds.
Monday 09 Sept 2013	
Morning	Calibration of rudder angle transducers while alongside.
? - ~1800	Transit to WCFA.
1800 - 2400	OTA
Tuesday 10 Sept 2013	
0000 - 0430	OTA
0430 - 1500	Perform trial runs (12.5 hrs)
1500 - 1730	OTA
1730 - 2130	Perform trial runs (4 hrs)
2130 - 2400	OTA
Wednesday 11 Sept 2013	
0000 - 0430	OTA
0430 - 1500	Perform trial runs (12.5 hrs)
1500 - 1730	OTA
1730 - 2130	Perform trial runs (4 hrs)
2130 - 2400	OTA
Thursday 12 Sept 2013	
0000 - 0430	OTA
0430 - 1500	Perform trial runs (12.5 hrs)
1500 - 1730	OTA
1730 - 2130	Perform trial runs (4 hrs)
2130 - 2400	OTA
Friday 13 Sept 2013	
Morning	Boat transfer of other trials' staff to Tofino as soon as practical (if req'd).
? - 2400	Perform trial runs (~8-12 hrs)

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Date	Activities
Saturday 14 Sept 2013	Perform trial runs* (~16 hrs)
Sunday 15 Sept 2013	Perform trial runs* (~16 hrs)
Monday 16 Sept 2013	
0000 - 0900	Transit from WCFA to Equimalt.
0900 - 1200	Fuel. Disembark DRDC trial team and kit.
1200 - 1700	Trial kit packed for shipment back to DRDC Atlantic.
Tuesday 17 Sept 2013	DRDC trial team return travel from Victoria to Halifax.

OTA = Other Trials' Activities.
*May return to Esquimalt once trial runs are completed.

Table 21: Estimated Run Set Times

Run Set	Estimated Time
Measured Miles	11 hours
Forward Turning Circles	26 hours
Astern Turning Circles	8 hours
Zigzags	5 hours
Direct Spirals	7.5 hours
Slow Speed Controllibility	1.5 hours
Acceleration/Coasting Runs	4 hours
Crash Stops	1.5 hours
Speed Reversals	1.5 hours
Sub-Total	66 hours
Optional Measured Miles	11 hours
Optional Zigzags	5 hours
Optional Acceleration/Coasting Runs	5.5 hours
Optional Speed Reversals	3 hours
Sub-Total	24.5 hours
Combined Total	**90.5 hours**

References

[1] 24th ITTC (2005), ITTC - Recommended Procedures and Guidelines: Preparation and Conduct of Speed/Power Trials, 7.5-04-01-01.1 revision 03 ed, Specialialist Committee on Powering Performance of 24th ITTC.

[2] National Defence and the Canadian Forces: Modernized HALIFAX Class (online), `http://www.materiel.forces.gc.ca/en/hcmf-mhc.page?` (Access Date: April 15, 2013).

[3] Cumming, D., McKay, S., and Millan, J. (1991), Results of the Measured Mile and Manoeuvring Trials Carried out on HMCS HALIFAX - August 1997: Volume I (U), (Technical Report TR-1991-13) National Research Council of Canada - Institute for Marine Dynamics. CONFIDENTIAL.

[4] DMSS 2-2-3 (2010), Trial Agenda for Post HCM/FELEX First of Class Standardization Trials Applicable to Halifax Class, (Technical Report C-23-HFX-000/NT-001) DND Canada.

[5] DMSS 2-2-3 (2010), Trial Agenda for Post HCM/FELEX First of Class Manoeuvring / Controllability Trials Applicable to Halifax Class, (Technical Report C-23-HFX-000/NT-002) DND Canada.

[6] 22nd ITTC (1999), The Specialist Committee on Trials and Monitoring: Final Report and Recommendations to the 22nd ITTC, The Specialist Committee on Trials and Monitoring.

[7] 25th ITTC (2008), The Manoeuvring Committee: Final Report and Recommendations to the 25th ITTC, The Manoeuvring Committee.

[8] (1993), Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions: STANAG 4194 Ed. 2, NATO.

[9] Masson, Lt(N) and Randell, CPO2 (2012), OOW Main Machinery Considerations. Presentation Brief.

[10] (2005), NAV420CA Series User's Manual, Document 7430-0121-02 Revision A ed, Crossbow Technology Inc.

[11] (2008), Model GS-101 User Guide, Revision e ed, ORCA Technologies. ORCA Technologies GPS and Time Code Instrumenation Products, GPS/IRIG-B Synchonized Time Code Generator.

[12] (2013), Ultrasonic flowmeters SITRANS FUP1010 IP67 7ME3510 Portable Flowmeter Operating Instructions - January 2013, SIEMENS, Siemens AG Industry Sector Postfach 48 48 90026 NÜRNBERG GERMANY.

[13] DMSS 2 (2000), Halifax Class General Load Monitor (GLM) Operator Guidance Booklet, Version 3 ed, Department of National Defence Canada.

Annex A: Draught Record Sheet

HMCS ____________________ **Trials Serial #** ____________________

❑ Deep ❑ Operational Light ❑ Towed Array

All Parameters Shall Be Recorded **Before** and **After** Each Day's Trials															
DATE		DRAUGHT (at marks)										TRIM [2]		Hog or Sag [3] (m)	List [4] deg
		FWD			MIDSHIP			AFT			Mean [1] Draught (m)	Over Marks (m)	Over LPP (m)		
		Port (m)	Stbd (m)	Avg (m)	Port (m)	Stbd (m)	Avg (m)	Port (m)	Stbd (m)	Avg (m)					
	Before														
	After														
	Before														
	After														
	Before														
	After														
	Before														
	After														

(1) Mean Draught = [Avg FWD + Avg AFT] /2

(2) Positive Trim is by the bow; i.e., +ve bow down

(3) Hog or Sag = (Mean Draught) – (Avg Midship Draught)

(4) The Ship's List may be read from the ship's clinometer, at the discretion of the Technical Authority

	Name	Representing	Signature	Date
Data Recorded By				

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Annex B: Tank Sounding Record Sheet

HMCS ____________________________ **Trials Serial #** ______________________

❑ Deep ❑ Operational Light ❑ Towed Array

DATE: __________________	**Departure** Time of Reading: ___________	**Return** Time of Reading: ___________

Readings are presented as:

❑ % Full ❑ volume (m^3) ❑ tonnes ❑ sounding (m) ❑ other ________

TANK IDENTIFICATION	**DEPARTURE** Reading	**RETURN** Reading	**COMMENTS**

Record is to be repeated for each day of trials. If fluids are discharged or taken on between departure and return readings, additional entries and explanations shall be provided in the comment section.

	Name	Representing	Signature	Date
Data Recorded By				

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Annex C: Load Items Record Sheet

HMCS ______________________ **Trials Serial #** ______________________

❑ Deep ❑ Operational Light ❑ Towed Array

DATE: ______________________

Estimate of stores, provisions and ammunition on board (percentage of full):
Missing items and non-standard or temporary fitted/carried items of significance:
Crew and effects on-board (relative to full/standard complement):
COMMENTS:
If significant change is made during the trials, this record shall be amended and explanation provided.

	Name	Representing	Signature	Date
Data Recorded By				

""""""

List of Acronyms and Abbreviations

A/D	Analog/Digital
ADM(Mat)	Assistant Deputy Minister (Materiel)
ASCII	American Standad Code for Information Interchange
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
BIS	Base Information Services
C.G.	Centre of Gravity
Cdr	Commander
CODOG	Combined Diesel or Gas
COG	Course Over Ground
COMSEC	Communications Security
DGMEPM	Director General Maritime Equipment Program Management
DGPS	Differential GPS
DMSS	Directorate of Maritime Ship Support
DNPS	Directorate of Naval Platform Systems
DRDC	Defence Research and Development Canada
EC	Engineering Change
ECPINS	Electronic Chart Precise Integrated Navigation System
FELEX	Frigate Life Extension
GHS	General Hydrostatics
GLM	GHS Load Monitor
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GT	Gas Turbine

HCI	Halifax Class IPMS
HCM	Halifax-class Modernization
HMCS	Her Majesty's Canadian Ship
IPMS	Integrated Platform Management System
ITAR	International Traffic in Arms Regulations
ITTC	International Towing Tank Conference
LED	Light-Emitting Diode
M/C	Manoeuvrability/Controllability
NDDS	Navigational Data Distribution System
NETE	Naval Engineering Test Establishment
NOAA	National Oceanic and Atmospheric Administration
NPOL	Naval Platform Operational Limits
ODAS	Ocean Data Acquisition System
OOW	Officer of the Watch
OTA	Other Trials' Activities
PDE	Propulsion Diesel Engine
PLA	Power Level Angle
PO	Petty Officer
RCN	Royal Canadian Navy
RPM	Rotations Per Minute
SJSL	Saint John Shipbuilding Limited
SOG	Speed Over Ground
SS	Sea State
UTC	Coordinated Universal Time
VHF	Very high frequency

WCFA West Coast Firing Area

WP Warship Performance

X-CONN Cross Connected

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This report presents a plan for standardization and manoeuvring/controllability trials for HMCS CALGARY which has recently completed its midlife modernization as part of the Halifax-class Modernization (HCM)/Frigate Life Extension (FELEX) program. Existing data for standardization and manoeuvring/controllability for the HALIFAX Class frigates is from a trial in 1991 on HMCS HALIFAX when the ships were newly built. This data is somewhat limited due to a number of technical problems encountered during the trial at that time. The ships now operate at a deeper displacement and have undergone a number of appendage changes. In addition to documenting the performance of the ships post HCM/FELEX refit, which is of primary concern to operators, the results of the trial will provide more complete and up-to-date information for ship simulators and research & operations modeling.

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Canadian Patrol Frigate (CPF); Halifax Class; Halifax Class Modernization (HCM); Frigate Life Extension (FELEX); sea trial; manoeuvring; fuel consumption; controllability

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