4. Warship Designs

This Chapter relates to the design work done on a ship-by-ship basis, and from time to time involves both the specific Design House and the shipyard staff in which the particular ship was built.

As has been mentioned elsewhere, the output of the Design House invariably required Production Engineering activity in order for the particular shipyard to build the ship in detail as produced by the Design House. This also meant that if a ship class were built in more than one shipyard, as in the case of the original seven St. Laurent Class, then there would certainly be some minor differences between all (in essence) seven “lead ships”. This posed a problem of configuration control so that as modifications to the ship class were produced over time the details of the design may well provide a clash in the actual build space of some of the ship class. However, ships being less congested and more able to accept minor variations than aircraft, this was not normally a major problem; e.g. ship stability was less stringent than aircraft centre of pressure and variation in mean aerodynamic chord.

This Chapter is sub-divided into 6 parts for convenience, viz:

4.1 Warship Design – one process followed in the design of a new warship as practised by MIL Systems Engineering.

4.2 DE’s to DDH’s Ship Classes - the design work carried out under the NCDO/MDDO contracts by the original Design Team assembled by Canadian Vickers. The design work for the various ship classes as shown in the chart contained in Chapter 1, Overview often overlapped time-wise. The design of the following warship classes were, however, contracted for separately.

4.3 FFH 330 Halifax Class - the Concept Design was provided by MIL Systems Engineering Inc. in Ottawa, Ontario. The Detail Design and associated Production Drawings were also provided 70% by MIL Systems Engineering and 30% by the Prime Contractor, St John Shipyard Ltd. in Saint John, New Brunswick, who contracted out much of its design work to specialist companies such as YARD Ltd. of Glasgow, Scotland for its expertise in anti-noise vibration mounting of main machinery packages, for example. Nine of the ships were built at Saint John Shipyard in New Brunswick, and the other three at the MIL Davie shipyard in Levis, Quebec.

4.4 FHE 400 Bras d’Or Class - the design work was carried out by de Havilland Aircraft of Canada in Downsview, Ontario, because the design philosophy was that the ship would utilize hydro-dynamic airfoils to sustain its mass whenever it performed at high speed. The ship was built by Marine Industrie at Sorel, Quebec.
4.5 DDH 280 Class TRUMP - the design work was carried out by MIL Systems Engineering Inc. and the modification of all 4 ships was carried out by MIL Davie at Levis, Quebec.

4.6 MCDV 700 Kingston Class - the design work was done by Fenco MacLaren of Toronto but all 12 ships were built at HalShips in Halifax, Nova Scotia.
As a prelude to this subject, it is useful to reproduce here the technical parts of a description of the process followed in the design of a warship by MIL Systems Engineering. The document was raised for the benefit of DSS personnel to facilitate their understanding of the complexity of the process, hence the minute detail that the work entailed. The description was raised under the supervision of Tom Campbell, who at the time was Senior Vice President, Operations at MIL Systems Engineering. Sections 3, 4 and 5 of the original document are reproduced hereafter.

SECTION NO. 3 - PHILOSOPHY OF WARSHIP DESIGN

Sub-Section A - Introduction

The start point of any Warship Design rests with the Crown who identifies a need and a Mission Profile of the warship.

A Technical Statement of Requirements defines the operational requirements of the warship and the specific requirements of the systems that are integrated into the operating entity - the ship.

This "wish list" supports the Mission Profile that the Crown has indicated as its need in the overall planning of Department of National Defence. The Mission Profile and Statement of Requirements represents the first technical communication that the designer has with the Crown.
SECTION NO. 3 - PHILOSOPHY OF WARSHIP DESIGN

Sub-Section B - Spiral Design

The overall approach to a warship design is from a systems engineering viewpoint which encompasses all design, Integrated Logistic Systems engineering and management activities necessary to integrate the ship, its installed subsystems, equipment and operators into a single system compatible with the specified operational tasks and performance requirements. It also encompasses integration of the ship system with the shore support systems and infrastructure.

The basic requirement for a warship is to support a payload and achieve a specified operational criteria (for example, a maximum speed in a particular sea state or noise or survivability). The payload consists of its combat systems and crew.

The desired payload and performance to be developed for the ship are defined in the Technical Statement of Requirements and the Integrated Logistics Concept. It is the task of the designer to develop these requirements into an achievable and balanced ship design and support infrastructure within the specified economic envelope. This will be achieved during Project Definition through the means of concept and preliminary design studies leading to the Production Design.

Preliminary design supported by trade-off studies will evolve the concept design into a balanced, feasible design which meets as many of the design requirements as can be technically and economically catered for within the cost and schedule constraints.

Designing a ship is essentially an iterative process based on new technology, sound engineering and skillful trade-offs. It can be described as proceeding along a spiral, the centre of which is hopefully reached when all the features making up the design have been balanced.

Figure No. 1 provides a graphic representation of this design spiral.

During the course of the design, each of the spiral loops will have been travelled successively, and within each individual loop several internal cycles around the entire loop or on various aspects of the design may be required in order to obtain "convergence" at the end of the loop.

This iterative process has to be developed within technical and economic constraints and, therefore, throughout the development of the design trade-offs between sometimes conflicting
requirements will have to be made. This trade-off process and the success of the ultimate design depends to a large extent on the skill and experience of the design team.

The design spiral depicted at Figure No. 1 emphasizes the intent that the design converges on a specific solution and indicates the sensitivity of the solution to a change in one of a number of features. It does not, however, convey the openness of the design process. Figure No. 2 suggests another model in which the classic design spiral can be seen as a section through a gradually converging conical solid. This allows for the many dialogues and constraints which operate on the designer to be shown as fundamental to the process. Figure No. 3 identifies three categories of constraints that impinge on the design of a ship:

a) those directly and usually explicitly stated
b) those directly limiting the scope of the designer
c) those wider constraints on the environment in which the designer functions

Figure No. 3 is a table which attempts to explain these categories by giving typical examples of each.

Given the basically multi-functional nature of warships, in that they have many, often conflicting requirements all of which have to be met to some degree, the designer's problem is one of achieving a balanced and adaptable solution. Any discussion of the ship design process which neglects the limitations imposed by constraints on the designer is unlikely to provide a real framework within which the design may proceed.
Figure 1
Figure 2
<table>
<thead>
<tr>
<th>Direct Constraints on the Design</th>
<th>Constraints Originating from the Design Process</th>
<th>Constraints Originating from the Environment</th>
<th>Constraints Originating from Physical and Natural Environment</th>
<th>Constraints Originating from Political Environment</th>
<th>Economic Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce manpower on the ship</td>
<td>Relationship of the designer with customer</td>
<td>Attitude of the design organisation to the latest design techniques</td>
<td>Data availability of past design type ship data available</td>
<td>Need to comply with new laws (e.g., health and safety during build)</td>
<td>The need for new technologies to improve product quality</td>
</tr>
<tr>
<td>Reduce time to build</td>
<td>Simplicity of production process in the factory</td>
<td>Design flexibility to buy in finished parts</td>
<td>Specialisation and training of design team</td>
<td>Design constraints directly on top and their limitations</td>
<td>Design constraints on the ship</td>
</tr>
<tr>
<td>Minimise time to refit</td>
<td>Minimise time to refit</td>
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<td>Minimise time to refit</td>
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</tr>
</tbody>
</table>

**Figure 3**

*Note: The above examples are not comprehensive. They serve to illustrate the differences in the three categories of constraints.*
Figure 4
SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section B - Mission Profile

The Crown's Mission Profile for the proposed Warship is
passed to the designer outlining the operational and performance
requirements.

The Mission Profile indicates a "wish list" of requirements
from which feasibility studies will be carried out during the
sequential design stages.

Warships, unlike aircraft are built without preliminary
prototype work and the R&D element tends to be overlooked.

Unless the Crown specifies an existing design variation, the
design at this point is nothing but a Blank Piece of Paper.

Unlike commercial type ships which are designed to meet the
rules of regulatory bodies, eg., Lloyds, warships are designed
using both existing technical calculation methods and other
methods still being developed to meet the specific requirements of
a new warship design.

The product from this point on represents R&D and not the
tasks or methods applied.

The risk factor at this stage of the design cycle is normally
accepted as ten (10) on a rating of one (1) to ten (10).
SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section C - Conceptual Design

The Mission Profile and the Statement of Requirements is the baseline data used to undertake the Conceptual Design.

The following highlights the approach to the concept design process:

- After a review of the baseline data, an estimate will be made of volume and dimensional requirements based on general arrangement features. Design studies/parametric trade-offs will be initiated.

- A matrix of ship forms will be generated from first principles covering the anticipated range of displacement and principal hull dimensions. A resistance prediction method based on standard series will generate data on this matrix and determine good values for hull form coefficients to minimize fuel consumption and for good seakeeping.

- A parametric study will be conducted based on principal hull dimensions and selected coefficients to determine hull form limitations imposed by seakeeping criteria.

- Available hull volume will be calculated as a function of main hull parameters. When compared to the volume required, this will impose constraints on the selection of hull dimensions.

- An estimate will be made of ship displacement. The displacement line becomes an additional constraint on the hull form selection.

- From the assembled data, the design point may be chosen. The effect of moving to any other design point should also be apparent.

- As the Concept Design proceeds, results of other design studies will be fed into the design. Dimensional and form changes will be made as appropriate so that the design point stays within the bounds of limiting criteria.

The complexity and uniqueness of integrating the very stringent requirements of a warship design can only be controlled and progressed through the iteration process as described in Section No. 3, Sub-Section B - Spiral Design.
There will be Design Reviews with the Crown to monitor the
Design Options. These Reviews will culminate with an agreed
Conceptual Design Baseline.

The risk factor will have decreased to nine (9) on a scale
of one (1) to ten (10).

SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section D - Preliminary Design

The Conceptual Design baseline is the data used to commence
the Preliminary Design.

The Preliminary Design stage may be defined as that set of
activities which will lead to one or more sets of definitive
Warship Designs, each of which "satisfies the Customer's Statement
of Requirements".

All major equipment options will be identified and assessed,
and a recommended system incorporated into a set of hull options.

The hull options will be sufficiently broad so that all
"Technically Feasible Combinations" of major equipments or systems
are defined and the subsequent choice of supplier (of major
equipment) will not cause major changes in weight, cost or
layout.

All potential major system equipment options will be identi-
fied.

Recommended systems/equipment options will be proposed and
supported by analysis in terms of operational capability, weight,
maintenance and cost.

It is not intended that tenders for various equipments and
systems be received during the Preliminary Design stage, therefore
weight and cost estimates must be based on best available inform-
ation.

The cooperative approach between the Crown and Designer is
monitored with Design Reviews. These Reviews generate a confi-
dence in the design process and establish a new Preliminary Design
baseline.

The risk factor is decreasing as the design data begins to
firm up.

The risk factor at the end of the Preliminary Design stage
will be seven (7) on a scale of one (1) to ten (10).
SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section E - Contract Design

The Preliminary Design baseline is the data used to commence the Contract Design.

The Contract Design is the development of the design option(s) accepted by the Crown after the last Design Review of the Preliminary Design stage.

Preliminary Design addressed major features whereas Contract Design will address the entire ship in greater detail.

During this stage it may be necessary to process one or more loops around the design spiral (Section No. 3, Sub-Section B-Spiral Design) to advance features such as:

- hull form based on a faired set of lines and model tests
- powering based on model testing
- seakeeping and manoeuvring characteristics based on model testing and computer analysis
- structural details and materials
- general arrangements
- machinery, electrical and electronic/weapons systems

At this stage equipments and systems requirements will be progressed to a point where definitive selections can be considered.

Tenders will be raised for the equipment and systems allowing the weight and cost estimates to be updated.

The design will continue to be monitored by the Crown and designer during the ongoing design reviews. These reviews tend to become more frequent as financial commitments have to be made on hardware.

The risk factor is further decreasing as the design is developed into a package where builders may be asked to price for construction.

The risk factor at the end of the Contract Design stage will be five (5) on a scale of one (1) to ten (10).
SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section F - Functional Design for Construction

The Contract Design baseline is the data used to commence the Functional Design which defines the transition phase into construction data.

At this stage of the design cycle new methods and concepts of ship construction are probably the most underestimated stage in the whole design process. Modular construction is not new to the industry in Canada, however module construction for warships has only been attempted in the projects listed in Section No. 6.

The Japanese shipbuilding industry are the leaders in this method but have only perfected the procedures for their commercial vessels which are less sophisticated and do not have the space or operational restrictions of a warship.

Three (3)-way review meetings take place between the Crown, designer and shipyard to discuss and agree on proposed design changes to facilitate the requirements of the shipyard.

It is hoped that the changes will not effect the design and performance requirements of the vessel, however one more loop around the design spiral is necessary to decrease the risk factor and achieve agreement amongst the Crown, designer and builder of this warship.

The factor at the end of the functional design for construction will be two (2) on a scale of one (1) to ten (10).

The equivalent of the aircraft prototype can now start to be built.
SECTION NO. 4 - WARSHIP DESIGN STAGES

Sub-Section G - Production Design and Trials

The Functional Design data is used to commence the Production Design.

During the construction stage of the project, the normal day to day problems are resolved through direct communication between the designer and the shipyard tradesmen.

There does however remain risk that new technology introduced at earlier phases cannot be accommodated as planned leading to rework and in some cases a revisiting of the design spiral.

The remaining design risk can only be removed at the successful completion of the systems and ship trials.

At this point in time the ship should successfully meet all of the State of Requirements and have a capability to perform to the Mission Profile for the Crown.

Thousands of engineers, technicians, draftsmen and tradesmen have had their input into the design and build of the first ship - THE PROTOTYPE.

SECTION NO. 5 - DESIGN RISK QUANTIFICATION

Sub-Section A - Introduction

To quantify the risk involved with a warship design one must appreciate Section No's 3 and 4.

The initial blank pieces of paper indicates a high risk to the completion of the trials with no risk.

The sub-section and figures included in this section identifies and quantifies the risk values through the whole design cycle.
SECTION NO. 5 - DESIGN RISK QUANTIFICATION

Sub-Section B - Risk Matrix

During the design stages of a warship, historically the risks are generally identified with the following areas:

- Hull Space and Weight Infraction
- Lines and Powering
- Propeller Design
- Stability, Damage Stability, Trim, Seakeeping
- Strength, Structural Design
- Machinery Selection
- Electrical Design
- Weapons Integration
- Signature, Noise, Vibration, Shock
- Vulnerability, Manning, Redundancy Considerations

The design problems associated with the risk areas interact with more than one discipline, i.e., the propeller design will effect the hull structure and lines.

The following matrices identifies this interaction and endeavours to quantify the risk value e.g., H - High; M - Medium; L - Low; N - Nil at the completion of each of the design stages.

The matrices are listed as follows:

Figure No. 5 - Mission Profile
Figure No. 6 - Conceptual Design
Figure No. 7 - Preliminary Design
Figure No. 8 - Contract Design
Figure No. 9 - Functional Design
Figure No. 10 - Production Design and Trials
<table>
<thead>
<tr>
<th>RISK AREAS</th>
<th>HULL SPACE &amp; WEIGHT INFRATION</th>
<th>LINES &amp; POWERING</th>
<th>PROPELLER DESIGN</th>
<th>STABILITY</th>
<th>DAMAGE STABILITY</th>
<th>TRIM</th>
<th>SEAKEEPING</th>
<th>STRENGTH</th>
<th>STRUCTURAL DESIGN</th>
<th>MACHINERY SELECTION</th>
<th>ELECTRICAL DESIGN</th>
<th>WEAPONS INTEGRATION</th>
<th>SIGNATURE, NOISE, VIBRATION, SHOCK</th>
<th>RISK &quot;A&quot; ON &quot;B&quot;</th>
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**FIGURE #5 MISSION PROFILE**
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Figure 6 Conceptual Design
<table>
<thead>
<tr>
<th>RISK AREAS</th>
<th>&quot;A&quot;</th>
<th>&quot;B&quot;</th>
<th>&quot;C&quot;</th>
<th>&quot;D&quot;</th>
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<th>&quot;F&quot;</th>
<th>&quot;G&quot;</th>
<th>&quot;H&quot;</th>
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<tbody>
<tr>
<td>Hull Space &amp; Weight Infract.</td>
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<td>Propeller Design</td>
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</tbody>
</table>
| Stability, Damage Stability, 
T.M., Seakeeping | | | | | | | | |
| Strength, Structural Design | | | | | | | | |
| Machinery Selection | | | | | | | | |
| Electrical Design | | | | | | | | |
| Weapons Integration | | | | | | | | |
| Signature, Noise, Vibration, 
Shock | | | | | | | | |
| Vulnerability, Manning, 
Redundancy, Considerations | | | | | | | | |

**Figure 7 Preliminary Design**
### Risk Areas

<table>
<thead>
<tr>
<th>Naval Architecture</th>
<th>Design</th>
<th>Outfitting</th>
<th>Systems</th>
<th>Auxiliary</th>
<th>Command &amp; Control</th>
<th>Electric</th>
<th>Propulsion</th>
<th>Structural</th>
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<td>Full Space &amp; Weight Infraction</td>
<td>Propeller Design</td>
<td>Stability, Damage Stability</td>
<td>Trim, Seakeeping</td>
<td>Machinery Selection</td>
<td>Electrical Design</td>
<td>Weapons Integration</td>
<td>Signature, Noise, Vibration, Shock</td>
<td>Vulnerability, Manning, Redundancy Considerations</td>
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**Figure #8 Contract Design**
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**Figure 19: Functional Design**
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<td>ELECTRICAL DESIGN</td>
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**RISK AREAS**

- Hull Space & Weight Impaction
- Lines & Powering
- Propeller Design
- Stability, Damage Stability, Trim, Seakeeping
- Strength, Structural Design
- Machinery Selection
- Electrical Design
- Weapons Integration
- Signature, Noise, Vibration
- Shock
- Vulnerability, Manning, Redundancy Considerations

FIGURE #10 PRODUCTION DESIGN & TRIALS
4.2 DE’s to DDH’s SHIP CLASSES
Designs & Ship Upgrading

All of the following warships were either designed and/or upgraded by the original Vickers Design Office staff under the NCDO/MDDO contract. The following data is prefaced in each case by extracts taken from “Jane’s Fighting Ships 1991-92” edited for Jane’s Information Group by Capt. Richard Sharpe RN (13), and from “The Ships of Canada’s Naval Forces 1910-1981” By MacPherson & Burgess (17).

DE 205 (St. Laurent Class)

<table>
<thead>
<tr>
<th>Name</th>
<th>Arm</th>
<th>Speed knots</th>
<th>Complement</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKEENA</td>
<td>207</td>
<td>15 Range, miles: 45 knots at 12 knots</td>
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</tr>
<tr>
<td>OTTAWA</td>
<td>220</td>
<td>15 Range, miles: 45 knots at 12 knots</td>
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</tr>
<tr>
<td>MARGAREE</td>
<td>220</td>
<td>15 Range, miles: 45 knots at 12 knots</td>
<td></td>
</tr>
<tr>
<td>FRASER</td>
<td>233</td>
<td>15 Range, miles: 45 knots at 12 knots</td>
<td></td>
</tr>
</tbody>
</table>

There were actually 7 ships in this class, viz:
- St. Laurent DE 205
- Saguenay DE 206
- Assiniboine DE 234
Destroyer Escorts

St. Laurent Class

HMCS St. Laurent, launched in 1952, was the first A/S vessel designed and built in Canada. She and her sister classed as Destroyer Esq. (DDEs), were originally armed with two 5-inch guns and two Lippo A/S mortars. Her 3-inch guns and quadruple 20mm Bofors were removed in a modernization effort in 1960. In 1975, she was modernized with a radar director and flight deck. Her armament was replaced by two 5-inch guns. The flight deck was adapted to the new armament, but the forward one was removed. The stern was modified to accommodate some Canadian development that was not part of the St. Laurent design, but four of them were rebuilt, from 1967 to 1972, with an A/S rocket launcher aft in place of the after turret, a disproportionately tall mast, and a stern redesigned to accommodate VDS. None of the four rebuilt carries a helicopter. The three not rebuilt, Chaudière, Columbia, and St. Croix, were reduced to Category 'C' reserve in 1974. St. Croix serves as a harbour training ship at Halifax; the other two lie at Esquimalt.

Restigouche Class

A second class of seven DDEs, the Restigouche class, entered service between 1958 and 1959. They approximated very closely the original St. Laurent design, but four of them were rebuilt, from 1967 to 1972, with an A/S rocket launcher aft in place of the after turret, a disproportionately tall mast, and a stern redesigned to accommodate VDS. None of the four rebuilt carries a helicopter. The three not rebuilt, Chaudière, Columbia, and St. Croix, were reduced to Category 'C' reserve in 1974. St. Croix serves as a harbour training ship at Halifax; the other two lie at Esquimalt.
DE 235 (Improved Restigouche Class)

<table>
<thead>
<tr>
<th>Name</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>GATINEAU</td>
<td>236</td>
</tr>
<tr>
<td>RESTIGOUCHE</td>
<td>237</td>
</tr>
<tr>
<td>KOOTENAY</td>
<td>238</td>
</tr>
<tr>
<td>TERRA NOVA</td>
<td>239</td>
</tr>
</tbody>
</table>

Displacement, tons: 2330 (standard), 2490 (load)
Constructions, feet (meters): 351' 4" (107.1)

Main machinery: 2 English Electric geared turbines; 30,000 shp;
2 shafts; 2 Babcock and Wilcox water tube boilers
Speed, knots: 28; Range, miles: 4750 at 14 km
Complement: 214 (13 officers)

Missiles: SSM: 8 McDonnell Douglas Harpoon during Gulf deployment in 1990;
A/S: Harpoonable ASROC Mk 112 octuple launchers O, 8 missiles; internal guidance to 16 to 10 km (7.9 to 4.76 miles); payload Mk 48 torpedoes. Replaced by a Harpoon during Gulf deployment.
Guns: 3 Vickers 3 in. (76 mm)/50 (twin) Mk 6; dual-purpose; 300 rounds; 50 rounds/minute to 17 km (10.6 miles); weight of shell 11 kg.
1 Vickers Phaeton and 2 foretop 40 mm/60 during Gulf deployment.
Torpedoes: 2 324 mm Mk 32 (2 triple) tubes O; Harpoon Mk 4B; anti-submarine; astern 1300 lignes homing 11 km (6.92 miles) at 40 knots; warhead 44 kg.
A/S mortars: 1 Limbo Mk 10 (3 tube) O; automatic loading; range 1000 m; warhead 32 kg; replaced by Phaeton during Gulf deployment in 1990.
Countermeasures: Decoys: 4 Loral Hysor GRDEC Mk 36 O; 4 launchers with 4 fixed launch firing boat deployed and IR flares to 5 km (2.8 miles); PleaseShelf: 4 fixed launchers during Gulf deployment in 1990.
EDM: County radar warning.
ECM: ULO-6 jammer.
Combat data systems: Litton ADUS; automated data handling; Links 11 and 14; SATCOM for Gulf deployments.
Fire control: FFC5 Mk 6.
Radars: Air search: Marconi SPS 403 (CMR 1820) O; EF band; range 120 km; 800 km.
Surface search: Raytheon SPS 10 O; G band.
Navigation: Deca 715 O; I band.
Fire control: Bell SPS 4A O; I band.
TACAN: JRN-25.
Sonars: Westinghouse 550/740; MKS-90; combined VDS and hull-mounted; active search, antisub and attack; 7 kHz.
C, Tech mine avoidance sonar for Gulf deployments.
SOV-20; hull-mounted; bottom target classification; high frequency.

Programmes: Officially classified as DD.
Modernisation: Three four ship were first fitted with ASROC aft and satcom foremast. Work included replacing the after 2 x 57 mm armament mounting and one Limbo A/S Mk 10 triple mount; to make way for ASROC and variable depth sonar. Work also included improvements to communications fit and complexed DE 73. Three other ships of the class were paid off and being refitted. All four modified again under Outo programme 1983-86 with new radar, GFC9, communications and EW equipment. The before DE and Tacon fitted on a pole mast replacing the tip of the lattice mast. Tripod Mk 32 suppressed below main mast.
Commissioned: 11 Feb 1983.

Operational: All based in the Pacific Fleet. Columbia (paid off 1974) is used as a training ship at Esquimalt. Terra Nova deployed to the Gulf in September 1990 had the ASROC launchers replaced by 8 Harpoon SSM; the Limbo Mk 10 by TACM and 12.7 mm MGs can be carried plus Blaine-car and Anguil. Rudder-stabilised SAM. Restigouche was modified in early 1981.

Actually, there were 7 ships in this class, viz:  
- Chaudiere: DE 235  
- Colombia: DE 260  
- St. Croix: DE 256
DE 261 (MacKenzie Class)

4 MACKENZIE CLASS

Name | No | Builders | Laid down | Launched | Commissioned
--- | --- | --- | --- | --- | ---
QU'APPPELLE | 264 | Davie Shipbuilding & Repairing | 14 Jan 1960 | 2 May 1962 | 14 Sep 1963

Displacement, tons: 2300 standard, 2800 full load
Dimensions, feet (metres): 396 x 42 x 13.5 (111.6 x 13.8 x 4.2)
Main machinery: 2 English Electric geared turbines, 30,000 shp
2 shafts, 2 Babcock and Wilcox water tube boilers
Speed, knots: 28 Range, miles: 4750 at 14 kts
Complement: 210 (11 officers)
Gun: 2 Vickers 3 in (76 mm)/70 Mark 6 mounting (twin) (not in QU'APPPELLE) G 90° elevation; 90 rounds/minute to 17 km (9.6 miles); weight of shell 11.7 kg.
2 FMG 3 in (76 mm)/50 Mk 33 mounting (twin) (second mounting fixed in QU'APPPELLE) G 90° elevation; 50 rounds/minute to 12.5 km (7.8 miles); weight of shell 6.4 kg.
Torpedoes: 2-324 mm MK 32 (2 triple) tube S Honeywell Mk 46; anti-submarine; active/passive homing to 11 km (6.8 miles) at 40 kts; warhead 44 kg.
Countermeasures: ESM, WiR 1; radar warning.
Combat data systems: Litton ADPS, automated tactical data handling: Link 11 and 14.
Fire control: GFCs MK 69, GFCs MK 83.
Radars: Air search: RCA SPS 12 G band; range 119 km (74 miles).

Mackenzie

Surface search: Raytheon SPS 10 G band.
Fire control: SPG 48 G 1/2 band.
SPG 34 (U) band.
Sonars: Westinghouse SOS 505; combined VDS and hull-mounted; active search and attack, medium frequency.
SOS 501; hull-mounted; bottom target classification; high frequency.

Programmes: Officially classified as DD.

Modernisation: All modernised at Esquimalt by Buran/Yarrow Inc under Detec (Destroyer Life Extension Programme) 1982-85 including improved sonar and communications, and modifications to SPS 12 radar. Extension until 1991-93 but may be further extended.

Operational: All based in the Pacific Fleet.

Mackenzie Class

The four Mackenzie class DDEs, which entered service between 1962 and 1963, essentially repeat the original Restigouche design, while the two Nipigon class DDHs of 1964 incorporated from their launching the design elements of the rebuilt St. Laurents, and carry helicopters.
DE 265 (Annapolis Class)

Iroquois Class

The four much larger “280,” or Iroquois, class DDHs carry two helicopters and are armed with a 5-inch gun, a Mark X A/S mortar, and a Sea Sparrow A/S missile launcher. The last of these was commissioned in 1973. Apart from the hydrofoil Bras d’Or they are the only Canadian warships to be powered by gas turbine engines.

DELEX

With a view to prolonging the lives of the 16 older destroyers, the Destroyer Life Extension Project (DELEX) was introduced in December, 1979. The procedure, which will be carried out by civilian ship repairers, is expected to take about 10 months per ship. In this way it is hoped, by 1987, that 12 years will have been added to the life expectancy of the Nipigon class and 8 years to that of the others.

The following page contains DELEX data as supplied by Alex Patterson, and is repeated herein from Chapter 3.4.
DELEX PROGRAM

The following vessels underwent the Destroyer Life Extension (DELEX) Program to varying degrees for various budget and different planned life extensions.

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Class</th>
<th>Cost/Ship</th>
<th>Planned Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDH 265</td>
<td>ANnapolis</td>
<td>$ 24 M</td>
<td>94</td>
</tr>
<tr>
<td>DDH 266</td>
<td>NIPigon</td>
<td>$ 24 M</td>
<td>94</td>
</tr>
<tr>
<td>DDE 261</td>
<td>MACKenzie</td>
<td>$ 12 M</td>
<td>90 - 93</td>
</tr>
<tr>
<td>DDE 262</td>
<td>SAS Katcheren</td>
<td>$ 12 M</td>
<td>90 - 93</td>
</tr>
<tr>
<td>DDE 263</td>
<td>YUKON</td>
<td>$ 12 M</td>
<td>90 - 93</td>
</tr>
<tr>
<td>DDE 264</td>
<td>QUAPPElle</td>
<td>$ 12 M</td>
<td>90 - 93</td>
</tr>
<tr>
<td>DDE 264</td>
<td>GATINEOR</td>
<td>$ 22 M</td>
<td>91 - 94</td>
</tr>
<tr>
<td>DDE 257</td>
<td>RESTIGouche</td>
<td>$ 22 M</td>
<td>91 - 94</td>
</tr>
<tr>
<td>DDE 258</td>
<td>Kootenay</td>
<td>$ 22 M</td>
<td>91 - 94</td>
</tr>
<tr>
<td>DDE 259</td>
<td>Terranova</td>
<td>$ 22 M</td>
<td>91 - 94</td>
</tr>
</tbody>
</table>

Conversion included:

- Removal of existing system
  - HM Search
  - A/S Mortar - Bojors Rocket Launcher
  - VPS
  - VDS Handling Gear
  - FH System
  - 3"/50 Gun Control System
  - Masts

- Installation of:
  - ADLPS
  - New HM Search
- Anti-ship Missile System - Super RBOC
  - New VPS
  - New VDS Handling Gear
  - Air Search Radar
  - New E/W System & GFC System
  - New Mast

- Relocation of:
  - Salvage Collection & Disposal Plant.

18-4-94
### DDH 280 (Iroquois Class)

**Destroyers / CANADA**  81

**DESTROYERS**

<table>
<thead>
<tr>
<th>Name</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>IROQUOIS</td>
<td>280</td>
</tr>
<tr>
<td>HURON</td>
<td>281</td>
</tr>
<tr>
<td>ATHABASKAN</td>
<td>282</td>
</tr>
<tr>
<td>ALGONQUIN</td>
<td>283</td>
</tr>
</tbody>
</table>

#### 4 TRIBAL CLASS

- **Builder:** Marine Industries Ltd., St. John
- **Marine Industries Ltd., St. John**
- **Laid down:** 15 Jan 1969
- **Launched:** 28 Nov 1970
- **Commissioned:** 29 Jul 1972

**Displacement:**
- **ton:** 4700 full load (5100 modified)

**Dimensions, Feet (meters):**
- **Length:** 526 ft. 11 in. (162.0 m)
- **Beam:** 54 ft. 6 in. (16.7 m)
- **Draft:** 19 ft. 0 in. (5.8 m)

**Main Machinery:**
- **CODOG:** 2 Pratt & Whitney F119A gas turbines; 50,000 shp; 2 Pratt & Whitney F112AM gas turbines (modified); 7400 shp; 2 GM Allison 501KF gas turbines (modified); 12,800 shp for cruising; 2 shafts; 6-bladed propellers

**Speed:**
- **knots:** 29.0

**Range:**
- **miles:** 4500 at 20 knots

**Complement:**
- **officers:** 256 (modified) / 236 (unmodified)
- **enlisted:** 320 (modified) / 246 (unmodified)

**Missiles:**
- SAM: 2 Raytheon Sea Sparrow (modified)
- **torpedo:** 32 (modified) / 24 (unmodified)
- **SAM:** 32 (modified) / 24 (unmodified)

**Gun:**
- 1 5" / 54 (127 mm) (modified) / 45 (unmodified)
- 1 5" / 60 (127 mm) (modified) / 45 (unmodified)

**Torpedo:**
- 2 Honeywell Mk 34 (modified)
- 1 5" / 60 (127 mm) (modified)
- 1 5" / 54 (127 mm) (modified)

**Countermeasures:**
- **CPOC:** 2, 330 nm (scaled)

**Fire control:**
- **SBS:** Mk 60 (modified)
- **SAR:** 330 (modified)

**Fire control radars:**
- **SBS:** Mk 60 (modified)

**A/S mortars:**
- 1 100 mm / 14 (24) (modified)

**A/S systems:**
- **TORPAC:** 2 (modified)
- **THINPAD:** 2 (modified)

**Helicopters:**
- 2 CH-124A Sea King ASW (see Operating)

**Modernization:**
- A contract for the Tribal Class Upgrade and Modernization (TRIM) project was awarded to United States Canada Limited in June 1986. The modernization gives the ships an area air defense capability provided by Standard SM 2 (MR) missiles fired from a Mk 41 Vertical Launch System (VLS). Other equipment fitted includes: OTO Melara 76 mm Super Rapid gun; Phalanx CIWS; LIM-45 SHARPS; SHMRP, and the Type AA-15 high frequency, long range radar; two Sea Sparrow launchers; and an ASW system.

**Structure:**
- These ships are fitted with a bridged deck equipped with double bulb bow and Beavertail frame type anti-rolling tanks to stabilize the ship at low speed, pre-wetting system to counter anti-air/active foil, enclosed cockpit, and bridge control of machinery. The frame type anti-roll tanks are replaced during modernization with a water displaced fuel system.

**Operating:**
- Atlakasak deploying to the Gulf in September 1990 had the Limbo mortar replaced by Phalanx CIWS and also carried Stroways and Hemis Javelin SAM systems in both shoulder-launched and lightweight versions. Additionally both helicopters carried 12.7 mm MADS and ESM instead of ASW gear. Navan similarly modified in early 1991.
The beautifully clean lines of the DDH 280 class hull (MIL Sorel 1969)

An example of ship space modelling of the engine room spaces for the DDH 280 class by Amie Bartien in Canadian Vickers before Computer Aided Design technology
AOR 508 (Provider Class)

**Displacement, tons:** 7300 (light); 22 000 (full load)
**Dimensions, feet (metres):** 594 x 76 x 32 (182 x 23 x 9.8)
**Main machinery:** Double-reduction geared turbine; 21000 shp,
shaft; 2 water tube boilers
**Speed, knots:** 21; **Range, miles:** 3600 at 20kts
**Complement:** 166 (15 officers)
**Cargo capacity:** 12 000 tons fuel; 900 tons aviation fuel; 250 tons dry cargo
**Helicopters:** 3 CH-124A Sea King ASW

**Comment:** The flight deck can receive the largest and heaviest helicopters. A total of 29 electro-hydraulic winches are fitted on
the flight deck for ship-to-ship movements of cargo and supplies, as well as shore-to-ship requirements when alongside. Based in
the Pacific Fleet, if sent to the Gulf she is to be given the same fit as Provider.

AOR 509 (Protecteur Class)

**Displacement, tons:** 8300 light; 24 700 full loaded
**Dimensions, feet (metres):** 564 x 76 x 30
**Main machinery:** General Electric steam turbine; 21 000 shp; 1 shaft;
boiler; 2 forced draught water tube boilers
**Speed, knots:** 21; **Range, miles:** 4100 at 20kts; 7500 at 11.5kts
**Complement:** 280 (28 officers)
**Cargo capacity:** 13 700 tons fuel; 400 tons aviation fuel; 1048 tons dry cargo; 1250 tons ammunition; 2 cars (15 tons lhd)
**Guns:** 2 x 76mm (x2); 1 x 40mm (x2); 2 x 20mm; 2 x 57mm
**Radars:** Surface search: SPG 502 with Mk XII/F/FF
**Navigation:** Sepiny Mk II; Radar/Decs TM 909; 1 band
**Sonars:** Westhollow SQS 555; hull mounted; active search;
** SONAR;** Mini mine avoidance for Gulf
**Helicopters:** 3 CH-124A Sea King ASW (see Comment)

**Comment:** An improved design based on the prototype Provider. Four replenishment positions. Both have been used as flagships
and troop carriers. They can carry anti-submarine helicopters,
military vehicles and bulk equipment for seafarers’ purposes; also
four LCVPs. For the Gulf deployment, the 76 mm gun was
replaced by two Vulcan Phalanx and two Bofors 40/60 guns fitted
and 4 Phoßen Steel Shock Launchers and AKA-76 ESM equipment
provided. Additionally all helicopters carried 12.7
mm Minigun and ESM equipment instead of ASW gear.

**OPERATIONAL SUPPORT SHIPS**
Operational Support Ships

PROVIDER (2nd)
PRESERVER (2nd)
PROTECTEUR

The first of this type, Provider, was commissioned on September 28, 1963, at Lauzon, Que. Originally designated as a fleet replenishment ship, she was the largest ship ever built in Canada for the RCN. She enabled RCN ships to remain at sea for extended periods, as well as greatly increasing their mobility and range. She has stowage space for some 12,000 tons of fuel oil, diesel oil, and aviation gas, in addition to spare parts, ammunition and missiles, general stores and food.

Experience with Provider led to significant changes in the design of the next two operational support ships, Protecteur and Preserver, commissioned at Saint John, N.B., on August 30, 1969 and July 30, 1970, respectively. Though similar in size to the tanker-like Provider, they have a higher freeboard, massive bridges, and paired funnels that make possible a single, much wider hangar door. Unlike Provider, the newer pair are also armed with a twin 3-inch “bow chaser” gun.

All three ships can refuel other fleet units at 20 knots, with automatic tensioning equipment to compensate for the ships' motion as fuel oil is transferred at 25 tons per minute. Each can carry three A/S helicopters as spares for the fleet or for transferring pallet loads of solid stores.
22 Class

Of the three light fleet carriers that were operated by the Canadian Navy, viz. HMCS Warrior, Magnificent and Bonaventure, only one underwent major retrofit design and subsequent upgrading in a Canadian shipyard. HMCS Bonaventure never re-entered service with the fleet subsequent to that major refit.
4.3

Halifax Class FFH 330

The following is an extract from “Jane’s Fighting Ships 1991-92” edited for Jane’s Information Group by Captain Richard Sharpe RN (13).

**FFH 330 (Halifax Class)**

<table>
<thead>
<tr>
<th>Name</th>
<th>No</th>
<th>Builders</th>
<th>Laid down</th>
<th>Launched</th>
<th>Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>VANCOUVER</td>
<td>331</td>
<td>St John S B Ltd, New Brunswick</td>
<td>19 May 1988</td>
<td>8 July 1989</td>
<td>1991</td>
</tr>
<tr>
<td>MONTRÉAL</td>
<td>336</td>
<td>St John S B Ltd, New Brunswick</td>
<td>1990</td>
<td>1993</td>
<td>1994</td>
</tr>
<tr>
<td>FREDERICTON</td>
<td>337</td>
<td>St John S B Ltd, New Brunswick</td>
<td>1990</td>
<td>1993</td>
<td>1994</td>
</tr>
<tr>
<td>WINNIPEG</td>
<td>338</td>
<td>St John S B Ltd, New Brunswick</td>
<td>1990</td>
<td>1993</td>
<td>1994</td>
</tr>
<tr>
<td>OTTAWA</td>
<td>341</td>
<td>St John S B Ltd, New Brunswick</td>
<td>1990</td>
<td>1993</td>
<td>1994</td>
</tr>
</tbody>
</table>

Displacement: 4750 full load
Dimensions, feet (metres): 440 x 408.5 x 15.3 x 18.1 (134.1 x 124.5 x 4.6 x 5.8)
Main machinery: 2 General Electric LM 2500 twin gas turbines; 45,000 shp
= 1 SEMT-Pielstick 20 P66-V280 diesel; 8600 shp at 1000 rpm
= 2 shafts; 3 propellers
Speed: knots: 28. Range, miles: 7100 at 15 knots (diesel); 4500 at 15 knots (gas)
Complement: 225 war; 185 peace

Missiles: SSM: 8 McDonnell Douglas Harpoon Block 1C (2 quad) launchers
= active radar homing to 130 km (70 nm) at 0.9 Mach, warhead 227 kg
SAM: 2 Raytheon Sea Sparrow Mk 48 e cats 4 vertical launchers
= semi-active radar homing to 14.6 km (8 nm) at 2.5 Mach, warhead 30 kg, 28 missiles (16 normally carried)
Guns: 1 Bofors 57 mm Mk 2 O; 77° elevation; 220 rounds/minute to 17 km (9 nmi); weight of shell 2.4 kg
1 GER/DCO 20 mm Vulcan Phalanx Mk 15; O; anti-missile; 3000 rounds/minute (6 barrels combined) to 1.5 km.
8–13.7 mm MGs
Torpedoes: 4–324 mm Mk 32 Mod 9 (2 twin) tubes
= 24 Honeywell Mk 46 Mod 1 or Mod 6; anti-submarine; active/passive homing to 11 km (6 nm) at 40 knots, warhead 44 kg.
Countermeasures: Decays: 2 Phased Shield decoy launchers
= triple mountings; fire PB Chaff and PB IR flares in distraction, decoy or centroid modes.
EMM: MEL Canavesi SLO 504 O; radar intercept. (0.5–18 GHz)
ECM: MEL Framus SLO 503 O; jammer.

**HALIFAX**

**Combat data systems:** SH/PAADS action data automation with YUG-504 and YUK-505 or 507 processors. Links 11 and 14.
Fire control: Sperry Aerospace SARR 8 RSTD (infra red search and target designation) to be fitted in due course. SWG-1(V) for Harpoon.
Radars: Air search: Raytheon SPS 49(V)5 O; C/D band; range 457 km (250 nmi)
Air/surface search: Ericsson Sea Giraffe HC 190 O; G band; range 40 km (21.8 nm) against missiles in clear conditions.
Fire control: Two Signal VM 25 STIR O; K/I band; range 140 km (75 nmi) for 1 m° target.
Navigation: Sperry Mk 340; I band.
Tactical: URI 501.
Sonars: Westinghouse SOS 505(V); hull-mounted, active search and attack; medium frequency.
DCD 501 SLO CANTASS towed array (uses part of Martin Marietta SDR 19 TACTASS).
DCD UYS 503(V); sonobuoy processing system.
Helicopters: 1 CH-124A Sea King ASW O; or 1 EH-101.

Programmes: On 29 June 1983 St John Shipbuilding Ltd won the long running competition for the first six of a new class of patrol frigates to be assisted by Parsons Electronics Inc of Montreal, a subsidiary of Unifi Co (formerly Sperry). Three were subconected to Marine Industries Ltd in Leasun and Scos. On 18 December 1987 six additional ships of the same design were ordered from St John Ltd. with delivery by 1990. Sometimes referred to as the City class. Halifax started sea trials 9 August 1989.

Structure: Plans to lengthen some of the class to increase SAR capacity and improve accommodation have been shelved. Much effort has gone into stealth technology. Gas turbine engines are still under consideration. Female accommodation is provided.

Opinion: These were the first new warships ordered in Canada since 1973 and should be good general purpose vessels with an emphasis on ASW. There have been delays in the original published programme but this is not unusual particularly for the first of class of a complex new design. In due course some variation of this design may be needed for the next generation of air defence ships.
The largest warship designed and built in Canada (pre 2003)

There was an open competition for the design and build of 6 Canadian Patrol Frigates - later 6 more were added (the CPF Program), which was won by Saint John Shipbuilding Ltd (SJS). However, the Crown preferred the Concept Design that Versatile Vickers had submitted as an integral part of its bid for the Prime Contract, and directed SJS to use that design rather than the Concept Design by Gibson & Cox of the USA included in the SJS submission. Versatile Vickers design unit was Versatile Vickers Systems Inc. (VVSI), which in 1987 became MIL Systems Engineering Inc. (MSEI) and the Detail Design was subsequently carried out by that company. However, some of the design requirement was kept by SJS itself (see Chapter 7.2 for some of the ramifications of this decision). SJS held the Prime Contract for the design, but sub-contracted the majority of the work to MSEI, as directed by the Crown. It kept to itself such aspects as the main machinery spaces and the rafting thereof, as well as the radar cross section signature of the overall ship. It contracted out this work to offshore companies, viz: Scotland and the USA. Hence that work does not qualify as Canadian Content, the objective of the CANDIB Study that prompted this publication. The Saint John Shipyard is currently closed down (2003) and no response to our enquiries for information for the CANDIB Study was forthcoming.

The following reproduced marketing pamphlet issued by MIL Systems Engineering summarises its role in the CPF Program. The MDDO Contract was invariably used by the Navy to carry out technical and feasibility studies for future warships, and the CPF Program was one example of this policy, and utilized the MDDO contract to a high degree in this regard starting as early as 1978. The subsequent technical requirement was then issued as part of the Bid Set for Industry to bid against. MIL Systems Engineering was, prior to the CPF Prime Contract Award, part of the Versatile Vickers Group as stated above and carried out the various studies to define the eventual requirement under the NCDO/MDDO contract.
THE DESIGN OF THE HALIFAX CLASS FRIGATE

The acquisition of the Halifax Class Frigate through the Canadian Patrol Frigate (CPF) program, represents the cornerstone of the Canadian Navy’s material modernization program and has been the most significant Canadian naval ship design activity since the Tribal Class (DDH 280). As with the Tribal Class, MIL Systems was involved with the CPF program from its outset. Starting in 1978 with the preparation of Contract Definition proposals, MIL Systems played a key role in the design of the ship and its systems.

The Halifax Class represents the state-of-the-art in Anti-Submarine Warfare vessels. The 134 metre vessel is powered by two LM2500 gas turbines and for superior range at cruise speed a medium speed diesel engine is also fitted. The vessel incorporates an extensive suite of above water and underwater sensors and countermeasures and is equipped to counter surface, air and underwater threats.

In support of the CPF Program, from 1978 to 1988, MIL Systems undertook feasibility studies and Concept Design of the ship platform and subsequently the Preliminary Design, Contract Design, and Functional Design of the ship platform, propulsion and service systems. In addition to providing 70% of the Production Drawings MIL Systems was also responsible for the integration of the combat system into the ship platform.

MIL Systems is proud to have been a leader in the design of this vessel.
In support of the CPF Program, MIL Systems provided an extensive range of design services:

- Feasibility Studies and Concept Design
- Preliminary Design
- Contract Design
- Functional Design
- Structural Design
- Propulsion System Design
- Vibration, Noise, Shock & Blast Engineering Analysis
- Electrical Generation & Distribution Systems Design
- Auxiliary & Outfit Systems Design
- Combat Systems/Platform Integration
- Equipment and Systems Specifications and Evaluation
- Production Drawings Preparation

The next reproduction is from the DND website and provides more definition of some of the equipment designed into the Halifax Class frigates by MIL Systems Engineering.
Saint John Shipbuilding Ltd is the prime contractor for the Halifax class frigate or Canadian Patrol Frigate programme. Nine of the twelve ships were constructed at the Saint John shipyards in Saint John, New Brunswick and three ships at Marine Industries Shipyards in Sorel. The multi-purpose frigates were commissioned between 1992 and 1997.

Halifax Class frigates, HMCS Regina and Fredericton, have been conducting maritime interdiction operations in the Persian Gulf in support of the international campaign against terrorism.

**COMMAND AND CONTROL**

The SHINPADS integrated processing and display system, supplied by Lockheed Martin Canada, provides a distributed architecture command and weapon control capability. The system uses about 15 AN/UYK-501 workstations manufactured by Computing Devices Canada.

The ship's Communications Control and Monitoring System (CCMS) was supplied by SED Systems of Saskatoon. Lockheed Martin Electronic Systems Canada supplied the message processing system.

**MISSILES**

The ship's surface-to-surface missile is the Boeing Harpoon Block 1C. The two quadruple launch tubes are installed at the main deck level between the ship's funnel and the helicopter hangar. The Harpoon missile uses active radar homing to deliver a 227kg warhead to a range in excess of 130km.

The Sea Sparrow vertical launch surface-to-air missile uses semi-active radar homing to deliver a 39kg warhead at speed Mach 1.6 to a range of 15km. The eight-cell launchers are installed port and starboard of the funnel.
GUNS

The main gun on the bow deck is a 57mm 70 Mark 2 gun from Bofors. The gun is capable of firing 2.4kg shells at a rate of 220 rounds/min at a range of more than 17km.

One Raytheon/General Dynamics Phalanx Mark 15 Mod 1 close-in weapon system is mounted on the roof of the helicopter hangar. The six barrels of the Phalanx provide a firing rate of 3000 rounds/min. The Canadian Navy has ordered upgrade kits to convert to the Phalanx Block 1B. The Block 1B upgrade includes a Thales Optronics HDTI5-2F thermal imager, improved Ku-band radar and longer gun barrel with a dual firing rate of 3000 or 4500 rounds/min. Deliveries of the kits began in September 2002.

TORPEDOES

The ship's two twin 324mm Mark 32 Mod 9 torpedo tubes are installed at the bow end of the helicopter hangar. The torpedoes are the ATK (Alliant TechSystems) Mark 46 lightweight anti-submarine torpedo. The torpedo has a speed of 45 knots and is equipped with active and passive homing and a 44.5kg warhead.

HELIicopter

The ship has a helicopter deck with a single landing spot. The deck is fitted with a RAST (Recovery, Assist, Securing and Traversing) system supplied by Indal Technologies of Ontario, allowing the launch and recovery of helicopters in up to Sea State 6. The hangar can accommodate a 15t helicopter such as the Sikorsky CH-124A Sea King.

COUNTERMEASURES

The ship's decoy system comprises four BAE SYSTEMS Shield Mark 2 decoy launchers which fire chaff to 2km and infra-red rockets to 169m, in distraction, confusion and centroid seduction modes. The torpedo decoy is the AN/SLQ-25A Nixie towed acoustic decoy from Sensytech Inc of Newington, Virginia.

The ship's radar warning receiver, the Canews (Canadian Electronic Warfare System), SLQ-501, and the radar jammer, SLQ-505, were developed by Thorn (now Thales) and Lockheed Martin Canada.

SENSORS

Two Thales Nederland (formerly Signaal) SPG-503 (STIR 1.8) fire control radars are installed one on the roof of the bridge and one on the raised radar platform immediately forward of the helicopter hangar. The ship is also fitted with Raytheon SPS-49(V)5 long-range active air search radar operating at C and D bands, Ericsson HC150 Sea Giraffe medium-range air and surface search radar operating at G and H bands, and Kelvin Hughes Type 1007 I-band navigation radar.
The sonar suite includes the CANTASS Canadian Towed Array supplied by Computing Devices of Canada (CDC) and CDC AN/SQS-510 hull mounted sonar and incorporates an acoustic range prediction system. The sonobuoy processing system is the CDC AN/UYS-503.

**PROPULSION**

The Halifax is powered by a CODOG (combined diesel or gas) system with two GE LM2500 gas turbines and one SEMT-Pielstick 20PA6 V280 diesel engine. CAE provide the Integrated Machinery Control System, which is being upgraded with flat screen monitors by December 2003.