National Defence / Défense nationale

Chief Review Services

REPORT ON CANADIAN PATROL FRIGATE COST AND CAPABILITY COMPARISON

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Canada

Interdepartmental Review of the Canadian Patrol Frigate Project: Report on Benchmarking of Cost and Capability

1.1 Summary

1.1.1 This report forms a component part of reporting on the Interdepartmental Review of the Canadian Patrol Frigate (CPF) Project. It presents an independent comparison based on manufacturer's performance specifications and costing information for the CPF relative to frigates built by several other countries during the same timeframe. This comparative analysis was performed by DND review staff in May 1995 essentially as background to other, more traditional assessments of aspects of the Project.

1.1.2 This analysis has concluded that, based on performance specifications, the CPF is a world-class fighting ship and that, in accordance with NATO costing conventions, the production cost for the last ship is reasonably competitive with other nations. The CPF exceeds the individual performance characteristics of its contemporaries in more aspects than it is equivalent or falls relatively short. These conclusions are ultimately founded on costing data and manufacturer's marine and combat system specifications obtained through extensive research of issues of Jane's Fighting Ships and Forecast International. Our literature search also supports the view that, notwithstanding considerable difficulties experienced in the early stages of the CPF Program, it succeeded in producing a multi-purpose frigate that has received positive international recognition.

1.1.3 There has been some criticism of this analysis, particularly as it appeared in first draft. These concerns have centered on elements of subjectivity. It has been suggested that increased levels of analytical sophistication be incorporated through the use of an expert panel as well as comparisons based on responses to defined threat scenarios. We have not taken these steps. However, in view of these comments, and the largely unavoidable element of subjectivity, the conclusions of the analysis have been limited. The review team is now confident that the conclusions of this independent analysis are appropriately qualified and reasonable in the circumstances.

1.1.4 The CPF Project Management Office (PMO) has also offered certain criticism of the analysis. The PMO has observed that a capability comparison is by necessity subjective, as the metrics on which to base an objective qualitative assessment of combat capability are generally not available. In response to the report, the PMO has cited the very positive conclusions of a similar, albeit more in-depth, 1997 analysis ***of*** *technological advances on several world class frigates performed by the Center for Security Strategies and Operations, the research and analysis arm of TECHMATICS, a Virginia-based firm. We were advised that this study was sponsored by the Prime Contractor for the CPF.*

1.1.5 Recent media reports have indicated that certain difficulties have been experienced, particularly with respect to CPF and Tribal Class missile firings. It would appear that these difficulties are attributable to a combination of factors related to operator training and technical attributes that were experienced in 1997 during exercises designed to test weapons systems at extended ranges in combat-like scenarios. Our work, which was substantially conducted in 1995, has not positioned us to provide independent comment on these more recent developments. Worthy of note, however is the caveat offered by the Centre for Security Strategies and Operations, that, "…the combat effectiveness of a complex weapons system under the stress of combat is difficult to measure." It is difficult for an equipment testing and evaluation regime to anticipate all potential combinations of operator, equipment and environmental interaction and conditions.

1.1.6 Other reports to be released as part of the Interdepartmental Review of the CPF are outlined in the table below.

Table 1: CPF Review Reports and Responsibilities

Area of Review	Review Organization
CPF Contract Management Framework	DND/Chief of Review Services (CRS) and PWGSC/Director General Audit and Review (DGAR)
Combat Systems Trainer Project (Contract Management)	Coopers and Lybrand under a contract jointly managed by DND/CRS and PWGSC/DGAR
Conflict of Interest	DND/CRS and PWGSC DGAR
Security of Information	DND Security and Military Police and PWGSC Internal Affairs/Industrial/Corporate Security.

2.1 Introduction

2.1.1 The analysis contained in this report was performed by DND review staff. The report presents weapon system specifications and costing information for the CPF relative to frigates built by 11 other countries during the same timeframe. This benchmarking information and analysis is not sufficient to support hard conclusions on the relative performance and cost of the ships. Rather it provides indicators which must be considered in the context of limitations on the level of sophistication of the analysis and on the availability of equally reliable information on all of the ships and for all of their characteristics and costs. However, information presented on

the CPF does have the benefit of considerable corroboration through systems-based audit work (separately reported) which was performed to, among other things: a) substantiate reported costs; and, b) determine that the Crown obtained what it contracted for and that a well executed program of equipment testing and evaluation/quality assurance (T&E/QA) was in place. Key sources of data on performance specifications and costs were the 99th edition of *Jane's Fighting Ships* and the annual US publication, *Forecast International/DMS Market Intelligence Report*. Although these sources primarily provide information on performance of navy combat and marine systems, our research also involved reference to several naval journals dating back to 1986 to determine costs and capabilities of other warships constructed in the same timeframe as the CPF. Information was also obtained directly from NATO contacts, other allies and from DND sources.

2.1.2 We recognize the challenges and limitations in performing a comparative analysis with other frigates. Ultimately, a degree of subjectivity cannot be avoided. Issues arise at the outset regarding, for example, weightings to be assigned to individual subsystem operating specifications. The National Defence Director of Maritime Ship Support (DMSS) advised us that allied naval architects have not agreed on weighting factors for the various capabilities. As well, it was difficult to balance the subsystem performance specifications with reliability/maintainability data that was not readily available. The sophistication of our analysis could also be enhanced through consideration of the response to threat scenarios. However, this would require reliable information on the tested capabilities of each ship, as well as agreement on the most pertinent threat scenarios; additional elements of subjectivity would undoubtedly result. Accordingly, the analysis seeks to minimize qualitative judgements on the part of the reviewers. We share the view that such an analysis would benefit from the application of expert opinion, ideally in the form of an expert panel. At this point, we have not taken that step.

2.1.3 It should also be noted that the country of origin of the particular frigates is not identified given that certain of the information presented was provided to the DND reviewers in confidence.

3.1 Conclusion

3.1.1 Our analysis indicates that the CPF is a world-class fighting ship and that, based on NATO costing conventions, the production cost for the last ship is reasonably competitive with other nations. The CPF exceeds the individual marine and combat system characteristics of other ships in decidedly more instances than it is equivalent or falls short. Additionally, our literature search suggests that, notwithstanding some bad press and difficulties experienced by the CPF Program in its early stages, by 1996 the Frigate has received positive international recognition from several expert sources.

4.1 Capability Comparison

4.1.1 The 11 ships that were selected to compare with the CPF are classified as frigates and are still in service with world navies operating in the North Atlantic and Pacific Rim. The weapon and platform characteristics were obtained from *Jane's Fighting Ships* and *Forecast International*. Weapon and platform operational characteristics are based on manufacturer specifications in optimum conditions, a common comparison baseline for all 11 frigates. In consultation with DMSS, the ship characteristics were divided into nine capability categories. Each type of weapon and sensor system was compared with criteria such as number of systems, range, rate of fire, and weight of fire. Platform capability comparisons such as survivability included: hull strength, damage control systems, noise reduction, infra red signatures, decoys, electronic counter measures, nuclear biological and chemical defence, and radar signature reduction.

4.1.2 As depicted in Figure 1, for each capability, CPF subsystem operational characteristics were assessed as equivalent, superior, or inferior to the subsystems of the other 11 frigates. Given that allies have not agreed on weighting criteria, we concurred with comments which challenged our earlier attempt to quantify the capability comparison by rolling up all nine capabilities into a total score. As such, Figure 1 uses a scorecard approach portraying the assessment as a qualitative comparison of each subsystem capability.

4.1.3 It is not our intention to provide an in-depth explanation of Figure 1. The details of this capability comparison and the methodology can be found in Annexes A and B respectively. Figure 1 provides an indication of the relative strengths of the CPF. These include its high degree of integration of combat and marine systems as well as its long-range deployment and endurance. The overall performance of the ship is further enhanced by its capacity to perform in multiple roles.

4.1.4 Our 1995 review of the CPF noted the early difficulties experienced by the Program. For example, the magnitude of the software integration that had to be achieved was perhaps unrivaled during the period and it experienced many of the problems typical of major software development projects at that time. The PMO attributes the greater part of early difficulties to the development of a warship-building capability in Canada. Particularly during the late 1980's and early l990's, the Program received some negative press prior to the acceptance of the first Frigate. An example is a September 1991 article *Canadian Patrol Frigate Trials and Tribulations*, which appeared in *Navy International*. However, consistent with our own observations and the results indicated by this comparative analysis, "expert" testimony encountered in our literature search of material prior to 1996 tended to corroborate the success of the Program. We make reference to certain articles appearing in professional journals. We

CPF Capability Comparison With 11 Frigates From Other Nations

Capability (Subsystem Groupings)	CPF	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6	Ship 7	Ship 8	Ship 9	Ship 10	Ship 11
Multi-purpose Roles												
Range, Crew Size												
Surface to Surface Weapons												
Air Defence												
Sub-surface Weapons												
Surface/Sub-surface Detection												
Close in Defence												
System Integration												
Survivability												

CPF Superior CPF Equivalent CPF Inferior

Figure 1

also cite remarks made to us by the US MITRE Corporation, a non-profit organization which provides technical support to the US government and which provided consulting advice to the CPF Program. The veracity of their assessment is considered against the backdrop of the very tough-minded reports that they delivered over the course of the Program.

4.1.5 The editor of one of the principal sources of information, *Jane's Fighting Ships*, a British publication, stated that "the Canadian City class are excellent modern warships"[1]. As well, *Forecast International*, a US publication which provides an annual assessment of warship capability and export potential, included the following commentary:

> After a very shaky start, mainly due to the long gap in Canadian warship construction, the Halifax class frigates have matured into fine warships. The lead ship of the class has been the subject of unstinting praise from the US Navy, following visits to American naval bases. HMCS Halifax is also regarded as being a very satisfactory and a well-conceived design by the British Royal Navy Directorate of Navy Construction.

4.1.6 We also noted during an interview with representatives of the MITRE Corporation, a major US consulting company that assisted the CPF program in rectifying weapon systems software integration difficulties, the following statement:

> The MITRE team had approximately 120 years of software consulting experience to bring to the CPF project. In comparison to other software development projects they have worked on, the CPF was one of the most significant in terms of integration complexity. Several US projects that were initiated in the 1960s took until the 1980s to fully mature with several necessary software upgrades. The CPF had successfully achieved a high level of maturity by the time of system acceptance.[2]

4.1.7 The difficulties experienced with the CPF system integration were due in some measure to the developmental nature of software design methodologies. However, as observed by the international naval journal *Naval Forces*, in a comparison of allied frigate command and control systems, the CPF combat systems distributed architecture was considered leading edge technology:

> The Canadian Navy and Unisys GSC deserve great credit for getting the first fully distributed surface ship command system into service. The City class patrol frigates have the Shipboard Integrated Processing and Display System (SHINPADS), a system which has impressed all who have seen it in action. What makes SHINPADS so advanced was the early recognition by the designers of the changing options in combat system architecture. A study initiated 20 years ago concluded that computer hardware costs were falling rapidly, and that single central processing computer systems were becoming obsolete.[3]

1 Ottawa Citizen, Capt Richard Sharpe, 23 February 1995
2 MITRE is a non-profit company that provides technical support to the US government.
3 Naval Forces, Seeing The Big Picture, Anthony Reston, November 1994, Volume XV

4.1.8 In response to an earlier draft of our report, the CPF Project Management Office provided a July 1997 analysis of frigate-type warships completed by the US CSSO. Annex C provides background information on this organization. The PMO has fully endorsed their analysis, suggesting that it is superior to that performed by the departmental review staff in 1995. The PMO has also informed us that the CSSO analysis was sponsored by the CPF prime contractor.

4.1.9 The objective of the CSSO analysis was to arrive at a detailed comparison of the CPF with other frigates in service by 28 June 1992, the date on which the lead ship, *HMCS Halifax*, entered service. The analysis includes a comparison of the *Halifax* to five l992 classes of frigate-type warships operated by allied nations. We have summarized the results of this CSSO analysis of the state of the art in 1992 frigate-type warships in Figure 2 in order to compare this assessment to the CRS analysis. As it happens, the overall results are not dissimilar to those that we have presented in Figure 1. The CSSO report also includes the following narrative summary:

> The *Halifax* incorporates several advanced state-of-the-art systems which are at the leading edge of international naval technology. While individually these systems provide only small incremental increases in warfighting capability, taken as a whole, their impact may be significantly larger. A few more seconds of additional reaction to surprise attacks, better and faster assessment of intelligence and information, automated decision making that minimizes the probability of human error and delay, the ability to absorb damage, and other features can combine to make the difference between ship survival and loss, between mission success or failure. Prior experience has shown that survivability counts. The ability to minimize the effects of an initial hit and to remain operational becomes paramount. Also, the modular design of the *Halifax's* combat system with redundant data buses provides more growth potential than the hardwired analog systems employed by most other frigates.
>
> The combat effectiveness of a complex weapon system under the stress of combat is difficult to predict and measure. In the case of both the British frigate *Sheffield* in the Falklands War and the US frigate *Stark* in the Persian Gulf, the ship's potentially effective self-defense systems were not employed because of human error. The completely automated combat system in the Halifax is therefore assessed to be an important advancement in the state-of-the-art of frigate-type warships.

4.1.10 We are not in a position to endorse the CSSO study. Neither do we have cause to doubt its veracity. However, throughout our analysis, we remained concerned that we had not afforded sufficient attention to the implications of the unprecedented levels of systems integration achieved by the CPF. To the extent that the CSSO study has validity, our analysis may understate the overall capability of the Frigates. Additional narrative excerpts from this study report appear in Annex D.

USA Center for Security Strategies and Operations
Comparative Analysis of the State of Art in
Frigate-Type Warships 1983 to 1992

Frigate Capability	**CPF**	**Ship A**	**Ship B**	**Ship C**	**Ship D**	**Ship E**
Command & Control Systems						
Communication Systems						
Machinery Control Systems						
Survivability						
Acoustic Signature						
Radar Signature						
Thermal Signature						
Self Defense Capability						
Anti-Submarine Warfare						
Surface to Surface Combat						

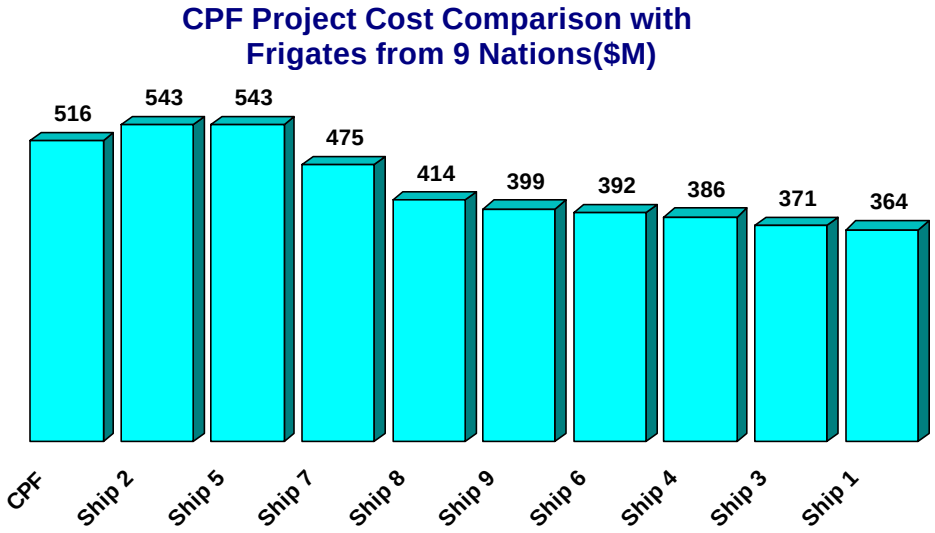
CPF Superior CPF Equivalent CPF Inferior

Figure 2

4.1.11 To supplement the field work completed in l995, the review team performed an examination of CPF post-deployment reports for the period l995-98. These would provide an indication of end-user perspectives on the performance of the ships. The results of this assessment can be found in Annex E. The indicators were generally favourable and corroborated 1995 interviews with CPF commanding officers and their staffs.

5.1 Cost Comparisons

5.1.1 Our research on relative costs encountered difficulty in obtaining equivalent costing information. Information available to us on the CPFs was understandably more all-inclusive than that which was available for other frigates. For example, certain of the ships were in production for some time and the costs we obtained may reflect only ongoing production costs - development costs are excluded. In addition, the contracting strategies employed in each country could well affect the costs reported to a project. A major objective of the CPF Program was to achieve a high degree of industrial regional benefits, as well as develop a national warship construction industry and electronics integration expertise. Our intent was to ensure that, to the



Costs based on contract awards, GFE and project mgt, less design & spares costs in 1995 Cdn$.

Figure 3

extent practicable, we achieved a comparison of like costs. In all of the cost comparisons that are presented, we factored in cost escalation rates during the period the frigates were under design and construction as well as currency exchange rates. The cost comparisons are based on 1995 Canadian current year dollars.

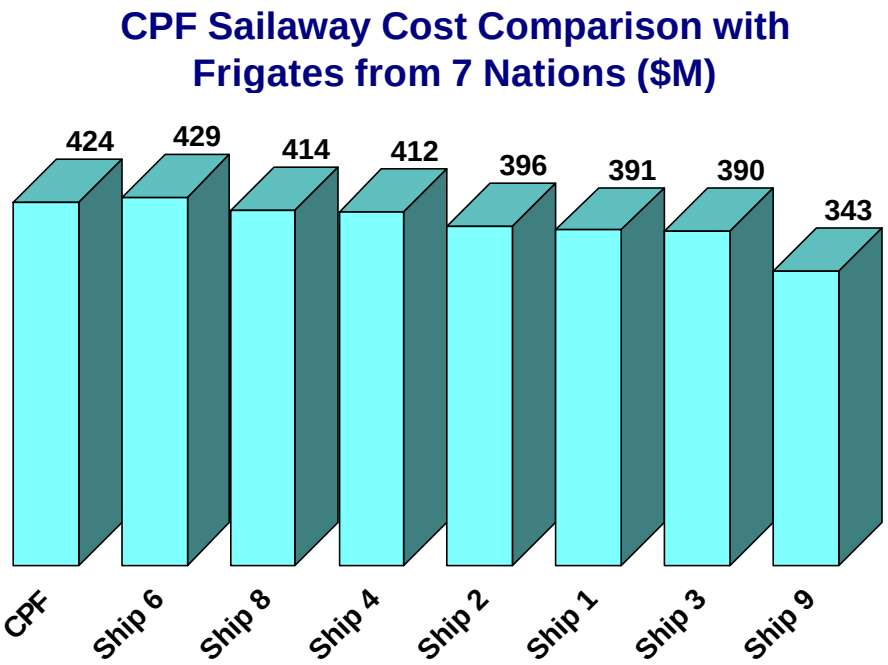


Figure 4

5.1.2 Figures 3 and 4 offer two perspectives on the costs associated with the frigates we reviewed. To varying extents, project costs depicted in Figure 3 will include such areas as contract award value, government furnished equipment (GFE), project management costs, training, quality assurance documentation and insurance. However, it was not possible to determine, for example, whether some contract awards included facility construction. In addition, unlike the CPF, many of the frigates had minor design changes from a previous class of frigates, resulting in smaller design costs. As it was not possible to capture the design costs of previous versions of the allied frigates, we excluded design costs for all of the frigates to ensure a common basis for the comparison. (In this respect, it has been correctly pointed out to us that exclusion of design costs would somewhat bias the comparison in favour of the CPF given that design and development costs would be amortized over a relatively small production run of 12 ships.)

5.1.3 In view of complications regarding the definition and availability of equivalent costing information, we have based our comparative analysis of costs on a NATO convention, Sail-away costs. These costs are depicted in Figure 4. They are based on a NATO-agreed Allied Naval Engineer Publication (ANEP-41) ship-costing convention. NATO Sail-away costs include ship construction, hardware, minor design changes, tests and trials, initial spares and fuel. These costs represent production costs and are quoted as export prices in the US publication *Forecast International*. (Sail-away costs were not available for all of the ships used for our comparison of capabilities.) However, as an additional indication of the difficulty in obtaining complete project costs, it is worth noting that, for ships 1, 3, 4 and 6, the Sail-away costs shown in Figure 4 are higher than the project costs depicted in Figure 3. This is clearly not the case for the CPF. Project costs from other nations may not reflect government subsidized shipyard costs or include infrastructure improvements.

5.1.4. It is also noteworthy that the Sail-away costs for ships 1, 3, and 9 are the lowest. However, some explanation may be provided by examining the differences in capabilities in Figure 1 and Annex A. The CPF is superior in size, range, crew endurance, stealth and towed array detection systems. As well, Ships 1, 3 and 9 do not have a multi-role capability. Use of the NATO ship-costing convention best permits the analysis to approach a comparison of like costs. It essentially approximates the export price of ships as reported in a recognized professional journal that we verified with other cost information. To the extent that it reflects the marginal cost of production, it is noteworthy that this cost declined steadily for the CPF, from $480M for the first ship to $424M for the last ship.

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CPF CAPABILITY COMPARISON WITH OTHER FRIGATES

CPF Audit Factors Reviewed in Frigate Capability Comparison

- Range/crew size
- Multi-purpose roles
- Combat and marine system integration
- Air defence
- Surface to surface weapons
- Subsurface weapons
- Surface/subsurface detection
- Close in defence
- Survivability

CPF Capabilities

- Range 9,400 km, maximum speed 29 knots
- Displacement 5,235 tons
- Crew size - 225 all ranks
- Multi-purpose - anti-submarine, anti-aircraft, surface to surface combat
- Integrated weapons, sensors, command and control
- Integrated machinery control system

Air defence

- 16 surface to air missiles (SAMs), 14.6 km range
- 57 mm gun, 17 km range, 220 rounds per minute (rpm), 77 degree elevation

Surface to surface missiles (SSMs)/weapons

- 8 Harpoon missiles, range 130 km
- 8 x 12 mm machine guns

Subsurface weapons

- 4 torpedo launchers, range 11 km
- Sea King helicopter, range 231 km

Surface/subsurface detection

- SPS 49 long range radar, range 249 km
- medium range radar, 100 km missile detection
- two fire control radars, range 140 km, 1 sq m target
- hull mounted sonar

- towed array sonar system
- helicopter deployed sonobuoys
- electronic intercept (CANEWS)

Close in defence

- 20 mm Vulcan, 1.5 km range, 3,000 rpm

Survivability

- shock tested hull
- noise reduction - raft mounted propulsion, air emission system
- infra-red signature reduction in exhaust stack
- radar absorbent material
- Shield infra-red and chaff decoys
- Nixie torpedo decoy
- electronic jamming (RAMSES)
- damage control system, automated fire repression
- redundant platform systems
- distributed command and control architecture
- nuclear, biological, chemical (NBC) defence overpressure system

Individual Ship Capability Comparison

- **Ship 1**

Inferior Characteristics

- 1,000 tons lighter than CPF
- 50 fewer personnel on crew
- Poor system integration
  - command and control system (CCS) contract let in 1995
- SAM range 6 km shorter
- Reduced maintenance facilities
- Inferior sensor suite

Superior Characteristics

- 114 mm gun, 5 km longer range, 25 rpm
- Two 30 mm close in weapon system (CIWS), 1.5 km longer range than CPF, 650 rpm
- 2,300 km longer range than CPF
- Low radar/noise signature

- **Ship 2**

Inferior Characteristics

- 1,150 tons lighter than CPF
- 3,400 km shorter range - gas turbine only
- Single shaft propulsion
- 19 fewer personnel on crew
- Poor system integration
- Single launcher air defence
- Poor survivability (infra-red, noise, radar)

Superior Characteristics

- 76 mm gun, 17 km range, 85 rpm
- SAM 30 km further than CPF
- Two more torpedo launchers
- Two helicopters

NB In instances where criteria were assessed as equivalent between the CPF and other frigates, no statement has been made.

- **Ship 3**

Inferior Characteristics	Superior Characteristics
• 1,500 tons lighter than CPF • 62 fewer personnel on crew • SSM not included - space available • No air emission or rafting • No NBC overpressure • Eight fewer SAMs • No close in weapon system	• 127 mm gun, 23 km range, 20 rpm • Two more torpedo launchers

- **Ship 4**

Inferior Characteristics	Superior Characteristics
• 1,700 tons lighter than CPF • 86 fewer personnel on crew • Inferior air defence - eight fewer SAMs • 60 km shorter SSM range • Four knots slower than CPF • No HMS or towed array - space available • No torpedoes	• Larger gun - 100 mm, 17 km range, 80 rpm • Two 20 mm guns • Low radar signature

NB In instances where criteria were assessed as equivalent between the CPF and other frigates, no statement has been made.

- **Ship 5**

Inferior Characteristics	Superior Characteristics
• 850 tons lighter than CPF • 3,500 km shorter range • 25 fewer personnel on crew • No towed array sonar	• Larger gun - 76 mm, 16 km range, 85 rpm • Two 20 mm guns • Superior air defence - 32 SAMs

- **Ship 6**

Inferior Characteristics	Superior Characteristics
• 550 tons lighter than CPF • 4,100 km shorter range • 26 fewer personnel on crew • Inferior system integration • No towed array • 88 km shorter SSM range • Older weapon and sensor systems	• Separation of sensors/weapons • Close in defence • 42 missiles, 9.5 km range • Two helicopters

- **Ship 7**

Inferior Characteristics	Superior Characteristics
• 2,000 tons lighter than CPF • 3,900 km shorter range • 52 fewer personnel on crew • No towed array sonar • No engine rafts or air emission	• Larger gun - 127 mm, 23 km range, 20 rpm • Two 20 mm CIWS • Six torpedo launchers • Two knots faster than CPF

NB In instances where criteria were assessed as equivalent between the CPF and other frigates, no statement has been made.

- **Ship 8**

Inferior Characteristics	Superior Characteristics
• 1,800 tons lighter than CPF • 1,900 km shorter range • 69 fewer personnel on crew • No engine rafts or air emission • Inferior towed array	• Larger gun - 76 mm, 12 km range, 85 rpm • 30 mm CIWS, .5 m longer range • Two 20 mm guns, 800 rds/min

- **Ship 9**

Inferior Characteristics	Superior Characteristics
• 1,300 tons lighter than CPF • 4,100 km shorter range • 55 fewer personnel on crew • No Integrated Machinery Control System (IMCS) • No towed array sonar	• Larger gun - 127 mm, 23 km range, 20 rpm • Two more torpedo launchers than CPF • Two 30 mm CIWS

- **Ship 10**

Inferior Characteristics	Superior Characteristics
• 3000 tons lighter than CPF • Four knots slower than CPF • 55 fewer personnel • Two less SSMs, shorter range • 10 less SAMs, shorter range • No torpedo system • No towed array sonar system • No torpedo decoy system	• Two 100 mm guns, 18 rpm, 22 km range

NB In instances where criteria were assessed as equivalent between the CPF and other frigates, no statement has been made.

- **Ship 11**

Inferior Characteristics	Superior Characteristics
• 2,700 tons lighter than CPF • 114 fewer personnel • No SSMs • No towed array sonar system • No helicopter • Only one fire control radar • No torpedo decoy	• Larger gun - 76mm, 85 rpm, 16 km range • Eight rocket launchers, 10 km range • Two more torpedo launchers than CPF

NB In instances where criteria were assessed as equivalent between the CPF and other frigates, no statement has been made.

Frigate Capability and Cost Comparison Methodology

1. **Ship Selection**. To ensure a common baseline, effort was made to only compare the same class of ships from different nations. Only ships that were designated as Frigate class were considered in the CRS Review. Frigates that were operational or under construction in the time frame after final acceptance of the first Canadian Patrol Frigate in December 1992 were selected for the comparison. Ships operating in the North Atlantic or the Pacific Rim were considered as recommended by the Office of the Auditor General.

2. **Information Sources**. Classified information of frigate trial results from 11 different nations was not readily available. Therefore, open literature was the primary source for performance specifications for weapon, sensor, and marine systems from annual publications such as *Jane's Fighting Ships and Forecast International/DMS Market Intelligence*. Nine other naval defense journals, listed in the bibliography, were researched back to the year 1989 to gain assessments of the capability of world class frigates as well as the value of contract awards. Costing information was provided by the Canadian Patrol Frigate prime contractor, Canadian defense liaison staff serving in allied nations and past surveys conducted by the project management office.

3. **Selection of Combat Capabilities**. The National Defense Director of Maritime Ship Support (DMSS) had performed limited comparisons of costs and capabilities in 1992. DMSS advised what categories of weapons, sensors and marine systems should be grouped in order to make a capability comparison. Nine different capability categories were recommended to assess the frigates capability relative to the Canadian Patrol Frigate:

- multi-purpose capability
- endurance (range/crew size)
- surface to surface weapons
- air defense weapons
- sub-surface weapons
- detection systems (surface/sub-surface)
- close in defense
- marine/ combat system integration

- platform survivability.

4. **Capability Comparison Criteria**. For each type of marine or combat system the optimal manufacturer performance specifications were compared in order to establish a common baseline for comparison. For each of the nine capabilities the CPF was assessed to be equivalent, superior or inferior to the capabilities of the other 11 frigates. The combat systems criteria were:

- the number of systems on the ship
- range of each system
- redundancy
- size of warhead
- rate of fire

For a ship platform capability such as survivability criteria included the following:

- Hull strength and testing
- Damage control systems and compartmentalization
- Noise reduction characteristics
- Radar and infra red signature reduction
- Electronic counter measures
- Availability of decoys such as torpedo decoys and chaff dispensers

5. **Overall Capability Assessment.** DMSS advised that allies could not agree on a weighting factor for each of the nine different capabilities that were compared. Therefore no effort was made to assign a quantitative score total for each the capabilities compared. Rather a qualitative approach was taken, assuming that each capability compared on 12 frigates carried equal weight.

6. **Costing Comparison.** Information on total frigate program costs was very difficult to obtain with the exception of the Canadian Patrol Frigate. Program costs for only nine of the 11 frigates were available. Currency exchange rates were taken into account to convert all costs to Canadian dollars. Historical escalation rates were also applied to convert current year dollars

into 1995 current year dollars. NATO sail away costs, defined in Allied Naval Engineer Publication (ANEP) 41, were only available for seven frigates from other nations as some ships were still not operational. Sail away costs represented the export prices or production costs of a ship including; ship construction, hardware, minor design changes, test and trials, initial spares and fuel. Where possible, to ensure the accuracy of the sail away costs provided by *International/DMS Market Intelligence,* they were compared to the same elements of the project costs from other sources. Although project costs were compared, design costs and initial provisionings were not included as this information was not available for all frigates. We had more confidence in the sail away costs than the ship project costs for the following reasons:

a. nations constructing a large number of frigates would have lower unit costs;

b. incremental design changes between each class of frigate would result in lower design costs than those nations who build ships less frequently with significant technological change between each class;

c. government subsidy of ship yards will lower the cost of ship production;

d. initial provisioning policy with respect to years of spare parts procured will impact project costs;

e. some nations may include navy infrastructure improvements in project costs; and

f. training requirements may not be included in project costs by some nations.

Center for Security Strategies and Operations (CSSO)

CSSO is the research and analysis arm of TECHMATICS, a technology, engineering, and professional services firm. From its facilities in Arlington and Fairfax, Virginia, the CSSO undertakes research, analysis and planning projects for government and industry, focusing its efforts in several key areas: aerospace, foreign policy and international security, defense, naval and maritime, counter-terrorism, emergency preparedness, strategic and operational intelligence, risk analysis, and threat assessments.

Excerpts from CSSO Comparative Analysis of the CPF and Other Frigate-type Warships

Of all the frigates analyzed the *Halifax* class emphasizes survivability to the greatest extent. It employs a steel superstructure, ballistic protection, redundant propulsion and electrical systems, a redundant distributed combat system, a survivable integrated communications system, a survivable propulsion control system, excellent automated damage control feature, a uniquely comprehensive NBC citadel, and is rigorously shock protected and designed to withstand nuclear air blast loads.

The *Halifax*, which is equipped with a medium-frequency, hull mounted sonar and a low-frequency, passive towed-array sonar, hull-launched torpedoes, and one large CH-124 Sea King helicopter, as delivered is the highest rated frigate with regard to anti-submarine warfare capability.

The *Halifax* is the only frigate analyzed that has an advance, state-of-the-art, fully distributed combat system, with a distributed command and control system linked by redundant data buses. The *Halifax's* command and control system is also fully automated for all modes of operations. This is assessed to be very important since it minimizes the probability of human error. The *Halifax* has a state-of-the-art fully automated and integrated external communications system using computerized circuit set-up monitoring, and reconfiguration. The *Halifax's* advanced state-of the-art broadband high frequency communications system is assessed to provide good performance while requiring relatively limited frequency management.

The *Halifax* has an advanced state-of-the-art machinery control system that is assessed to be unique in that it is completely digital and based on six multi-function electronic displays in four redundant locations. The machinery control system also interfaces with the computerized damage control system.

End User Capability Assessment

To determine the end user assessment of the CPF capabilities, post deployment reports for the 1995 – 1998 time frame were examined in detail by the review team. These reports included operations in United Nation forces in the Adriatic sea, participation in the NATO Standing Naval Force Atlantic (SNFL), combined and joint operations with NATO allies, and national exercises/missions. Overall, the post deployment reports indicate that commanding officers are satisfied with the operational capability of the CPF. The post-deployment reports confirm the interviews conducted in 1995 with the CPF commanders and their staffs. In particular, the reports highlight the following CPF capabilities:

- Communications interoperability with allies
- Effective engagements by combat systems, including the destruction of incoming sea skimming drone targets
- Superior direction finding and navigational capability in shallow water Adriatic operations (10 meters depth)
- Designation by NATO as the SNFL anti-submarine warfare (ASW) coordinator due to ASW capabilities
- Acceptable performance of critical equipment for deployments in environments with extreme temperatures.

Within the CPF project, funding was available to take advantage of technological improvements that evolved during the project. There are favourable reports by CPF commanders and staffs on the performance of the upgraded hull mounted sonar and the navigation radar. A modern local area network has also been installed on the CPF with upgraded printers.

Post-deployment reports record other operational deficiencies that have been addressed by the PMO. For example, the restrictions on the diesel engine cruise speed have been lifted since the replacement of the connecting rods, a design fault. As well, to address minor deficiencies and enhance the command and control software (CCS) there have been four Navy Versions to improve the integration of the CPF weapon and sensor systems. We observed that some CPF subsystems that are in service with several other navies require a high level of maintenance such as diesel generators, the close in weapon systems and the fire control radar. However, our trend analysis of in-service maintenance costs for the last four years indicates there is no increase and that they are relatively low compared to the Tribal class – a recently upgraded Canadian warship similar in size and capability to the CPF.